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Water, sanitation, hygiene and diarrheal diseases in the Aral Sea area (Khorezm, Uzbekistan)

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ABSTRACT

The Aral Sea region is a synonym for environmental disaster which is considered to cause various human health problems. However, epidemiological evidence was still lacking.

The vast majority of the rural population in Khorezm district, Uzbekistan, situated on the lower Amu Darya River in the Aral Sea Basin, relies on drinking water from groundwater wells. The piped drinking water in Khorezm is mainly abstracted from surface waters. Both drinking water sources are suspected to be frequently fecally contaminated. Since the consumption of fecally polluted drinking water implies a high incidence rate of waterborne disease, it is surprising that official epidemiological data – obtained by passive monitoring – show a considerable decline in incidences of waterborne infectious diseases.

This study aimed to create active monitoring data on the incidence of diarrheal diseases and to study the risk factors water, sanitation and hygiene. For the epidemiological data collection, a self-reported monitoring of diarrheal diseases was conducted during a 12-week period in summer 2003 and a 4-week winter follow-up in February 2004. Each of the 186 randomly selected households entered all diarrhea episodes on a daily basis into a diarrhea diary, which was checked and exchanged by interviewers weekly. For the determination of risk factors linked to drinking water hygiene, sanitation and hygiene a standardized questionnaire was designed with a focus on the following points: drinking water issues (collection, storage, treatment), health-related behavior of households, knowledge on diarrhea (causes, prevention, treatment) and domestic hygiene. Twice during the 12-week survey period, the drinking water storage vessels and the sanitation facilities of every household were checked for hygiene conditions. Forty drinking water sampling points (piped water, dug wells, tube wells, drinking water storage vessels) were monitored on a weekly basis for the fecal indicators coliform bacteria, enterococci and heterotrophic plate count bacteria during the summer follow-up.

In contrast to the official data, the study does not show a peak of diarrheal diseases in July, but high, almost stable incidences were revealed for the period between May and August. Children aged under two faced the highest diarrheal disease burden with 8.4 episodes per person year. For the other age groups, the episodes per person year ranged between 2.4 and 1.7. In winter, the same age distribution was determined. The fecal contamination of the drinking water increases between May and July, but the level of the contamination is dependent on the water source.

In the risk factor analysis assessed the public domain was included concerning variables on drinking water sources and kindergartens. The domestic domain of disease transmission was considered taking into account aspects such as household drinking water issues, health-related behavior, food hygiene and domestic hygiene including sanitation facilities and their maintenance as well as sewage disposal. The analysis revealed that visible contamination of drinking water during storage and absence of anal cleansing material were associated with the number of diarrhea episodes per household.

Overall, the findings of the study show that the domestic domain plays a major role with regard to fecal-oral disease transmission in Khorezm. Unhealthy excreta disposal habits and unsafe drinking water storage practices have to be tackled most urgently in order to break the fecal-oral transmission route.

Wasser, Abwasser, Hygiene und Durchfallerkrankungen in der Aralseeregion (Khorezm, Usbekistan)

KURZFASSUNG

Die Aralseeregion gilt als Synonym einer ökologischen Katastrophe, die als Auslöser zahlreicher Gesundheitsprobleme angesehen wird. Deren ursächliche Zusammenhänge sind bisher kaum epidemiologisch belegt.

Die Mehrheit der ländlichen Bevölkerung von Khorezm (Usbekistan) am unteren Amu Darya Fluß im Aralseebecken deckt den Trinkwasserbedarf aus Grundwasserbrunnen. Das zur zentralen Versorgung benötigte Trinkwasser wird hauptsächlich aus Oberflächenwasser aufbereitet. Beide Rohwässer stehen im Verdacht häufig fäkal verunreinigt zu sein. Da der Genuss von fäkal kontaminiertem Trinkwasser hohe Inzidenzen wasserbürtiger Erkrankungen impliziert, ist es erstaunlich, dass offizielle epidemiologische Statistiken – durch passives Monitoring erhoben – eine beträchtliche Verminderung der Inzidenzen wasserbürtiger Erkrankungen belegen.

Ziel der vorliegenden Studie war die Erhebung von Daten zu tatsächlichen Häufigkeiten von Durchfallerkrankungen durch aktives Monitoring sowie eine Analyse der Risikofaktoren Wasser, Abwasser, Entsorgung menschlicher Fäkalien und Hygiene. Im Rahmen der epidemiologischen Datenerhebung dokumentierte jeder der zufällig ausgewählten 186 Haushalte, im Sommer des Jahres über den Zeitraum von12 Wochen und im Februar 2004 für 4 Wochen, täglich alle in der Familie auftretenden Durchfallepisoden in einem "Krankheitstagebuch", das wöchentlich von einem Interviewer überprüft und ausgetauscht wurde. Die Daten zu den Risikofaktoren Trinkwasserhygiene, Abwasser, Entsorgung menschlicher Fäkalien und Hygiene wurden anhand eines standardisierten Fragebogens erhoben, der Trinkwasser (Gewinnung, Lagerung, Aufbereitung), Gesundheitsverhalten, Wissen über Durchfallerkrankungen (Ursachen, Prävention, Behandlung) und Hygiene im häuslichen Umfeld berücksichtigte. Zusätzlich wurden während der 12-wöchigen Befragung, im Sommer 2003, zweimal die hygienischen Verhältnisse von Trinkwasseraufbewahrungsgefäßen und sanitären Anlagen evaluiert. Vierzig Trinkwasserprobenahmestellen wurden wöchentlich auf die Fäkalindikatoren coliforme Bakterien und Enterokokken sowie die Gesamtkeimzahl untersucht.

Im Gegensatz zu offiziellen Zahlen konnte die Studie keinen Erkrankungsgipfel der Durchfallerkrankungen für den Monat Juli, aber hohe und kaum schwankende Inzidenzen für den Zeitraum Mai bis August belegen. Die höchste Inzidenz trat bei den unter Zweijährigen mit 8,4 Episoden pro Personenjahr auf. In den übrigen Altersgruppen schwankte die Anzahl der Episoden pro Personenjahr zwischen 2,4 und 1,7. Die Befragung im Winter wies denselben Trend für die Verteilung nach Altersklassen auf. Die fäkale Belastung des Trinkwassers stieg zwischen Mai und Juli an, das Ausmaß der Kontamination schwankte jedoch in Abhängigkeit von der Herkunft des Wassers erheblich.

Die in der Risikoanalyse berücksichtigten Faktoren spiegeln das öffentliche Umfeld durch die Variablen Trinkwasserherkunft und Besuch von Kindergärten wider. Die verwendeten Variablen für das häusliche Umfeld schlossen die Trinkwasserhygiene, das Gesundheitsverhalten, die Lebensmittelhygiene und die Hygiene im häuslichen Umfeld einschließlich der sanitären Einrichtungen, deren Wartung und der Abwasserentsorgung ein. Die Risikoanalyse zeigt, dass die sichtbare Verschmutzung von gelagertem Trinkwasser sowie das Fehlen von Hygienematerial zur Analpflege mit der Anzahl der Durchfälle pro Haushalt assoziiert sind.

Die vorliegenden Ergebnisse zeigen, dass das häusliche Umfeld in Khorezm eine wichtige Rolle bei der Übertragung fäkal-oraler Erkrankungen spielt. Die hygienisch unsachgemäße Entsorgung menschlicher Fäkalien und die inadäquate Lagerung von Trinkwasser müssen unverzüglich bewältigt werden, damit der fäkal-orale Übertragungsweg unterbrochen wird.

Вода, санитария, гигиена и заболеваемость диареей в регионе Аральского моря (Хорезм, Узбекистан)

АБСТРАКТ

Десятилетия пренебрежения вопросами окружающей среды и экономический спад в регионе Аральского моря привели к деградации качества воды, почвы и воздуха. Экологическая катастрофа и её влияние на окружающую среду являются источником многочисленных проблем для здоровья человека. Однако, все еще недостаточно эпидемиологических исследований, доказывающих причинно-следственные отношения между качеством окружающей среды и здоровья. Уровень заболеваемости болезнями органов дыхания и диареей поразительно высокий, однако это не обязательно непосредственно связано с экологическими условиями, а скорее с его социально-экономическими последствиями. Автономная Республика Каракалпакстан в Узбекистане граничит с Хорезмской областью, которая наиболее подвержена высыханию Аральского моря. Эти территории расположены в низовьях реки Амударьи, и их население сталкивается с типичными водными проблемами регионов расположенных в нижнем течении.

Приблизительно 51% населения Хорезма использует открытые колодцы или небольшие скважины в питьевых целях. Основными источниками водопроводной воды в Хорезме являются поверхностные водные объекты. Содержание микроорганизмов в этой питьевой воде, как известно, связано с высоким уровнем взвешенных твёрдых частиц в природной воде, неудовлетворительным состоянием источников водоснабжения и нерегулярностью водоснабжения. Согласно официальным данным, за прошлое десятилетие микробиологическое качество воды в централизованных системах водоснабжения значительно ухудшилось. Безусловно, что потребление фекально-загрязненной воды для питья ведет высокому уровню инфекционных заболеваний водной этиологии. Однако, официальные данные – полученные посредством пассивного мониторинга – показывают значительное сокращение числа инфекционных заболеваний водного происхождения. Таким образом, совокупная частота заболеваний гепатитом А в Хорезмской области уменьшалась с 395 до 103 случаев на 100 000 населения между 1991 и 2001годами. Уровень заболеваемости диареей показывает подобную картину.

Цель этой научной работы заключается в создании активного мониторинга для сбора данных по распространённости заболеваний диареей и изучение таких факторов риска их возникновения как вода, санитария и гигиена. Учитывая во внимание сложность проблемы, был выбран междисциплинарный подход в изучении, комбинирующий применение количественных и качественных методов исследования. 186 домашних хозяйств были случайно отобраны из трех административных районов Хорезмской области. Количество избранных городских и сельских домашних хозяйств отражает соотношение городского и сельского населения в соответствующей административной единице. В итоге, 40 источников питьевой воды находились под наблюдением в течение 12 недель. Количество точек отбора проб воды по типу источника отражало соотношение населения, использующего соответствующие источники питьевой воды.

Для сбора эпидемиологических данных использовался приём мониторинга, на основе самонаблюдения заболеваний диареей, который проводился в двенадцатинедельный период летом 2003 года и последующий четырехнедельный зимний период в феврале 2004 года. Жители каждого домашнего хозяйства ежедневно регистрировали все случаи диареи в так называемый «дневник диареи», который еженедельно контролировался и заменялся интервьюерами. Для определения факторов риска связанных с гигиеной питьевой воды, санитарией и бытовой гигиеной была разработана анкета, сосредотачивающая внимание на следующих пунктах: проблемы питьевой воды (сбор, хранение, очистка), отношение членов домашнего хозяйства к своему здоровью, их осведомлённость о диарее (причины, лечение, профилактика) и гигиенические навыки. В течение двенадцатинедельного периода исследования, ёмкости для хранения питьевой воды и санитарные принадлежности каждого домашнего хозяйства были дважды проверены на соблюдение гигиенических требований.

На протяжении летнего периода, питьевая вода из различных источников – водопроводная вода, открытые колодцы, качалки и ёмкости для хранения питьевой воды – были проверены на наличие индикаторов фекального загрязнения, колиформных бактерий, энтерококков и общего числа гетеротрофных бактерий. Дополнительно, были определены такие параметры качества воды как нитраты, общее содержание солей, мутность и запах.

В отличие от официальных данных, исследования не подтверждают пик заболеваемости диареей в июле. Однако, высокая, почти устойчивая, частота заболеваний была выявлена в летний период между маем и августом. Самое высокое бремя заболеваемости диареей, 8.4 случаев на человека в год, приходилось на детей в возрасте до двух лет. Для других возрастных групп, заболеваемость колебалась от 2.3 до 1.7 случаев на человека в год. Общая частота заболеваний для детей в возрасте до пяти лет насчитывала летом 4.6 случаев, а зимой 2.6 случаев. Зимой, та же самая тенденция распределения по возрасту была выявлена в пяти случаях на человека в год для самой малолетней возрастной группы и в пределах диапазона от 0.9 до 1.6 случаев на человека в год для других возрастных групп.

Результаты анализов воды показывают постоянное увеличение уровня микробного загрязнения для всех типов точек отбора проб между маем и июлем; тогда как фекальное загрязнение между различными типами точек отбора проб показывает существенные различия. Приблизительно 25% проб воды водопроводов в доме и проб из колодцев подтвердила наличие индикаторов фекального загрязнения. В кранах расположенных на улице было обнаружено приблизительно 50% заражённых проб, а в ручных насосах, после осуществления заливки, 38% заражённых проб.

Самое высокое фекальное загрязнение было обнаружено в открытых колодцах (> 60%) и ёмкостях для хранения воды в домашних условиях, где через несколько недель до 100% проб выходили за пределы допустимого уровня по показателям общего микробного числа гетеротрофов и энтерококков.

Анализ фактора риска показал переменные, которые зависят от мест общественного или домашнего пользования при фекально-оральном пути передачи инфекции, а также от социально-экономических условий. Переменные относительно мест общественного пользования включали источники питьевой воды и детские сады. Источник бытовой передачи инфекции был рассмотрен, принимая во внимание такие аспекты как вопросы гигиены питьевой воды в домашних условиях, поведение членов домохозяйств направленное на сохранение здоровья, гигиена питания и домашняя гигиена, включая состояние санитарного оборудования и их обслуживание. Анализ показал, что заболеваемость диареей в исследованных домохозяйствах связана с загрязнением питьевой воды во время хранения и отсутствием должного внимания средствам личной гигиены.

В целом, полученные исследования показали, что недостаточное соблюдение гигиенических правил в ведении домашнего хозяйства играет существенную роль в фекально-оральном пути передачи инфекции в Хорезме. Существующая практика утилизации фекалий и хранения питьевой воды являются самыми неотложными проблемами, которые требуют рационального решения для предотвращения фекально-орального пути передачи инфекций в данном регионе.

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ABBREVIATIONS

ANOVA	Analysis of variance
BMBF	German Federal Ministry for Education, Science, Research and Technology
CAR	Central Asian Republics
CCP	Critical control point
CFU	Colony forming unit
C. freundii	*Citrobacter freundii*
DOTS	Directly observed short-course
E	Enterococci
E. coli	*Escherichia coli*
Ecosan	Ecological sanitation
EU	European Union
FC	Fecal coliforms
GDP	Gross domestic product US$ per capita
GDWQ	Guidelines for drinking water quality
GEF	Global Environment Facility
GLM	General linear model
GOST	Russian National Standard
HACCP	Hazard analysis critical control point
HH	Household
HPC	Heterotrophic plate count
MPN	Most probable number
MSF	Médecins Sans Frontières (doctors without borders)
OBLSES	Regional Centers of Sanitation and Epidemiology
OBLSTAT	Regional Department on Statistics
OBLZDRAV	Regional Department on Public Health
ORS	Oral re-hydration salts
ORT	Oral re-hydration therapy
POU	Point-of-use
ppp	Purchasing power parity
TMC	Total microbial count
UDHS	Uzbekistan Demographic and Health Survey
UN	United Nations
UNDP	United Nations Development Project
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children Education Fund
USAID	The United States Agency for International Development
WHO	World Health Organisation
ZEF	Center for Development Research

TABLES

FIGURES

1 GENERAL INTRODUCTION

1.1 Health issues in the Aral Sea area

The health conditions of five million people living in the environmentally degraded Aral Sea area became public at the beginning of the 1990s.

In 1997, Médecins Sans Frontières (MSF) started a medical program in the worst affected region Karakalpakstan, Uzbekistan. Having recognized the urgent need for research into the links between environmental situation and human ill health, MSF launched an operational research program in order to encourage scientists to carry out environmental health research in the Aral Sea area. MSF also stated that well researched evidence and qualitative data were scarce. Moreover, skepticism about the validity of official data and the need for independent research was determined (Small et al., 2003; van der Meer, 1999).

The situation has not changed much since then; research evidence is still strikingly insufficient. A keyword database search in Medline for publications until April 2005 using the term 'Aral Sea' delivers 65 matches, of which 15 (23%) articles elaborate on water issues and health in general. Another 14 (22%) articles refer to studies about the flora and fauna of the region and 36 (55%) mostly recent articles are dealing with specific studies on human health. In addition, non-peer reviewed publications were hand-collected during field trips and at different conferences.

During the 1980s, high morbidity and mortality rates – especially in Karakalpakstan – led to the perception of environmental health problems as a consequence of the drying up of the Aral Sea and its implications, like the degradation of soil and water (Sharmanov, 1989) as well as changes in the regional climate. In the beginning, studies on environmental health on maternal and child health (Ataniyazova, 1995; Ataniyazova et al., 1994; Ataniyazova et al., 1995) including nutritional anemia (Morse, 1994) were carried out. As children are the most vulnerable group, some recent research also focused on children's health (Hashizume et al., 2003; Hashizume et al., 2004; Jensen et al., 1997; Kaneko et al., 2003; Kaneko et al., 2002; Khusainova et al., 2004; UNICEF, 1996).

In the Aral Sea area, the rates of tuberculosis in adults and in children (Absadykova et al., 2003; Zakharova and Piataeva, 1992) are the worst in all of Europe and the former Soviet Union. Owing to this fact, MSF conducted the very successful directly observed short-course (DOTS) program to combat tuberculosis (Kittle, 2000; Shafer et al., 2001) and multidrug-resistant tuberculosis (Cox et al., 2004).

While infectious diseases are not necessarily related to the environmental situation, chronic diseases are associated with the environmental conditions. Hypertension, respiratory conditions, heart disease, anemia, cancer and kidney disease are considered to be linked with environmental conditions such as: high salinity of drinking waters, pesticides in the environment, dust storms and poor air quality (Small et al., 2001).

Four studies deal with excessive intake of calcium and sodium via ingestion of drinking water and renal diseases (Fayzieva et al., 2002; Kaneko et al., 2003; Kaneko et al., 2002; Riabinskii et al., 1993). Poor air quality due to airborne dust containing salts and pesticides as well as incidence of respiratory diseases are addressed by three studies (Kunii et al., 2003; O'Hara et al., 2000; Severin et al., 1995).

Due to the heavy use of pesticides during the times of the Soviet Union, soils and water are contaminated with persistent organic pollutants, which then accumulate in the food chain. Studies by MSF demonstrated that long-lasting organochlorine pesticides and their metabolites can be found in all foods of animal origin and in some vegetables such as onions and carrots. While in the vegetables only low levels were detected, fat from animal origin like sheep fat, dairy cream, eggs and edible cottonseed oil contained high levels of dioxins. “Intake estimations demonstrate that consumption of even small amounts of locally grown food may expose consumers to dioxin levels that considerably exceed the monthly tolerable dioxin intake levels set by the World Health Organization” (Muntean et al., 2003). In humans living in the Aral Sea area (Kazakhstan and Karakalpakstan) high levels of organochlorine pesticides were measured in breast milk (Hooper et al., 1997) and cord blood (Ataniyazova et al., 2001) as well as in blood (Erdinger et al., 2004; Mazhitova et al., 1998).

Since health perception is strongly associated with psychosocial factors, another research by MSF examined the contribution of the environmental disaster to the well-being of people living in Karakalpakstan. The results demonstrate that the majority of the respondents reported their health status either fair (43%) or poor (12%). In doing so, environmental conditions are commonly perceived to be the cause of somatic symptoms and are significantly related to the self-rated health status (Crighton et al., 2003a; Crighton et al., 2003b).

Further human health concerns refer to a lack of health and hygiene education among the population and water issues (van der Meer, 1999). For the period since the independence, official data show a strong decline for all acute intestinal infections. In contrast to official data, at the same time there was important anecdotal evidence that prevalence and incidence of diarrheal diseases in the Aral Sea region are among the highest in the former Soviet Union. In a randomized intervention study by (Semenza et al., 1998) – using household drinking water chlorination – revealed the suspected high incidence of diarrheal diseases in Karakalpakstan. So far, for Uzbekistan this is the only study into the relation between diarrheal diseases and the risk factor water. Needs assessments and feasibility studies within the framework of the ‘Rural Water Supply Program’ and the ‘Water Supply, Sanitation and Health Project’ revealed an urgent need for improvements in water supply, sanitation and hygiene (Harris and Manila, 1998; Kudat et al., 1995; Oldham, 1999; Oldham, 2000; Oldham et al., 1999). It was, however, beyond their focus to establish causal relationships.

The development of strategies for a sustainable improvement in water-related health needs to be tailored to cultural demands. This requires a full understanding of links between water supply, sanitation – primarily human excreta management –, health-related behavior, domestic hygiene issues and disease outcomes. This study provides a comprehensive insight into common local practices and establishes a knowledge basis for the development of adapted holistic management strategies.

1.2 Implications of freshwater demand in the Aral Sea Basin

At present, 69% of the global freshwater resources are utilized for agricultural needs (UNESCO, 2003). In the future, food production – for the world’s increasing population – will demand even more water allocation to the agricultural sector (Falkenmark and Lannerstad, 2004). As a result of political changes implicating administrative restructuring like the formation of new states, water is increasingly becoming a contentious issue especially in regions situated downstream. The rivers Amu Darya and Syr Darya as well as the Aral Sea have become international waters since the independence of the Central Asian Republics. This impedes water management on a river basin scale and creates water problems – because of the enormous water demand needed for irrigated agriculture – being worst in the downstream countries, namely Turkmenistan and Uzbekistan (SIWI, 2000). Freshwater shortage is regarded to be responsible for about 70% of the developmental problems in Central Asia (Severskiy, 2004).

One of the instruments to overcome struggles for water is the ‘Convention on the Protection and Use of Transboundary Watercourses and International Lakes’ (‘Water Convention’). As water is essential to human health not only in terms of food production, but also for drinking water purposes and other domestic needs, the ‘Protocol on Water and Health’ (‘London Protocol’) was adopted under the Convention in 1999. The ‘London Protocol’ addresses water-related diseases in the European region with a holistic approach including prevention, control and reduction of water-related diseases by means of safe drinking water supply, adequate sanitation and basin wide protection of national and transboundary watercourses (WHO, 2001). So far, the Republic of Uzbekistan has signed neither the Convention nor the Protocol.

Water issues continue to dominate international environment protection and developments agendas. Thus, the Millennium Development Goal No. 7 targeting environmental sustainability includes halving the proportion of people without access to safe drinking water by 2015 (United Nations, 2000). Although the water needed to cover drinking water demands and domestic hygiene purposes amounts only to 8% of the annual global water consumption (UNESCO, 2003), in 2002 still about 1 billion people had no access to a safe drinking water supply.

Progress towards achieving the Millennium Development Goal on access to water supply and sanitation is monitored by the Joint Monitoring Program on Water Supply and Sanitation of WHO and UNICEF. The terminology used in the Joint Monitoring Program on Water Supply and Sanitation report has to be clarified: first, how is ‘drinking water’ defined; second, how do you measure ‘access’; and third, what is the difference between ‘safe’, ‘basic’ and ‘improved’ drinking water supply and sanitation? Drinking water is defined as water used for drinking, hygiene and other domestic purposes. Access to safe drinking water and improved sanitation is measured by the percentage of population using an improved water source or an improved sanitation facility (WHO and UNICEF, 2004). It is important to be aware that the term 'safe water supply' does not imply hygienically safe water neither in the sense of microbiological quality nor of chemical water quality. It refers solely to accessibility and type of source.

According to this report (WHO and UNICEF, 2004) for 2002, a total of 89% (97% urban, 84% rural) of the Uzbek population had access to a safe drinking water supply and 53% (85% urban, 33% rural) had a household connection to the drinking water supply network. The coverage with improved sanitation was 57% (73% urban, 48% rural). Since safe drinking water supply and sanitation are two sides of the same coin, only improvements in both facilitate substantial health benefit (Anonymous, 2004). This is also addressed by Millennium Development Goal No. 7 with the aim to cut the proportion of people without access to improved sanitation by 50% until 2015. Due to these inseparable linkages, progress in meeting Millennium Development Goal No. 7 contributes at the same time to the health-related Millennium Development Goals. However, still about 2.6 billion people worldwide lack improved sanitation (WHO and UNICEF, 2004) and 1.6 million deaths are directly attributed to unsafe water supply, sanitation and hygiene (SIWI, 2005).

Waterborne sewerage causes in turn new environmental and health concerns by converting freshwater into enormous amounts of fluid waste, which has to be safely disposed. Otherwise, "beyond the direct impact to human health, in the end, pollution of freshwater, food insecurity, destruction and loss of soils, loss of biodiversity, destruction of the ozone layer and global warming is occurring" (Esrey, 2000).

The people living in the Aral Sea area, in particular on the south sea shore, face serious water quantity and water quality problems in agriculture as well as with water for human consumption and other domestic purposes. Urgently needed sustainable water management concepts must not only consider public health aspects of these water problems, but also focus the priorities on the mutually public health impacts of drinking water supply and sanitation as well as on potential interventions.

1.3 The German-Uzbek Khorezm project

The German-Uzbek Khorezm project 'Economic and Ecological restructuring of Land and Water Use in the Region Khorezm (Uzbekistan)' financed by BMBF is an interdisciplinary pilot project in development research, carried out under the auspices of the UNESCO. The project includes several studies based on an interdisciplinary approach incorporating environmental, economic and social aspects. The common factor joining these studies is the resource water and its utilization for agriculture and drinking purposes as well as its socio-economic effects. Each of these water utilizing sectors requires a specific water quantity and quality and in turn has an impact on the resource. Overstretching water use in one sector affects quality and quantity demands of the same or another sector. For example, leaching of the saline agricultural land needs a high amount of water, which is then lacking during the irrigation period. Additionally, surface waters and herewith source waters for drinking purposes become contaminated with agricultural chemicals. Although, unsustainable land and water use on a small scale – like farm or household level – also has an impact on water quality issues, it is often neglected.

Only a balanced utilization of the scarce resource water on all scales (household, farm, regional, national, international) can create a satisfactory situation for all stakeholders and mitigate the ecological, economical and socio-economical problems in the region. Therefore, the interdisciplinary research approach of the project addresses water issues on those different scales. Randomized surveys and participatory approaches are applied on household and farm level. Projects referring to the regional scale use study sites along two transects in Khorezm, which intersect seven out of ten districts. The national and international scale is addressed by studies on legal-administrative reorganization.

1.4 Research objectives

The interrelations between water supply, sanitation, hygiene and diarrheal diseases are rather complex. Research objectives studying these links can only be met using an interdisciplinary approach. In this observational study, the incidence of diarrheal diseases and the risk factors such as water supply, sanitation, and hygiene are analyzed using a combination of quantitative and qualitative methods. The main objective of this study is to measure the association between diarrheal disease and the risk factors on household level.

Specifically, the study aims to:

1. Create active monitoring data on the incidence of diarrheal disease
2. Identify risk factors for diarrheal disease
3. Identify health-related behavioral habits

In view of these objectives, the following research questions are posed:

- What is the population at risk?
- How is the knowledge status on causes, prevention and treatment of diarrheal diseases among the population?
- What is the drinking water source quality?
- What is the point-of-use drinking water quality?
- How is drinking water collected, treated and handled?
- What is the status of domestic sanitation?
- What is the status of food hygiene?
- What is the status of domestic hygiene?
- What kind of health care seeking behavior is prevailing?

2 STUDY AREA AND DATA MINING RESULTS

2.1 Introduction

A brief introduction into the regional geography of Uzbekistan is followed by results from the data mining on demographic, health and water issues. In order to facilitate better comparability of the data, results are narrowed down from the national level to the Aral Sea region and finally to the Khorezm level. Where possible, comparisons are made with other Central Asian Republics (CAR) or with the European Union (EU).

Uzbekistan is a landlocked country in Central Asia. The country extends over 447,400 km^2 and includes the southern part of the Aral Sea. Desert covers about 70% of the country and about 11% are arable land; the latter is mostly situated in river valleys along the course of the rivers Amu Darya, Syr Darya and Zarafshan. A predominantly (semi-) arid climate with long, dry, hot summers and cold to moderate winters is one of the restricting factors in agricultural production. Uzbekistan is rich in natural resources and exports gas, petroleum, heavy metals and precious metal.

Since 1991, Uzbekistan has been an independent republic with a presidential democracy. The Supreme Assembly adopted the Constitution in December 1992.

Administratively, Uzbekistan consists of 12 provinces (Uzbek *viloyat,* Russian *oblast*), the autonomous Republic Karakalpakstan and its capital Tashkent. Each province is further divided into administrative districts named *tumani* (Uzbek) or *rayoni* (Russian). The study area, Khorezm *tuman,* is located about 400 km south of the Aral Sea and borders on Karakalpakstan.

2.2 The desiccation of the Aral Sea and its ecological effects

The Aral Sea is fed by two rivers: the Amu Darya (water flux 78 km^3/year) and the Syr Darya (37 km^3/year) (FAO, 2003). Both are transboundary watercourses whose river heads are situated in the Pamir Mountains and the Tien Shan, respectively. They belong to the countries Tajikistan, Afghanistan, Turkmenistan, Uzbekistan, Kazakhstan and Kyrgyzstan. The waters of the Amu Darya and the Syr Darya have been extensively exploited by the bordering countries for decades (Létolle and Mainguet, 1996). Upstream countries prefer management strategies promoting hydro-power generation, whereas the needs of ‘downstreamers’ are predominantly irrigation (Rost, 2004).

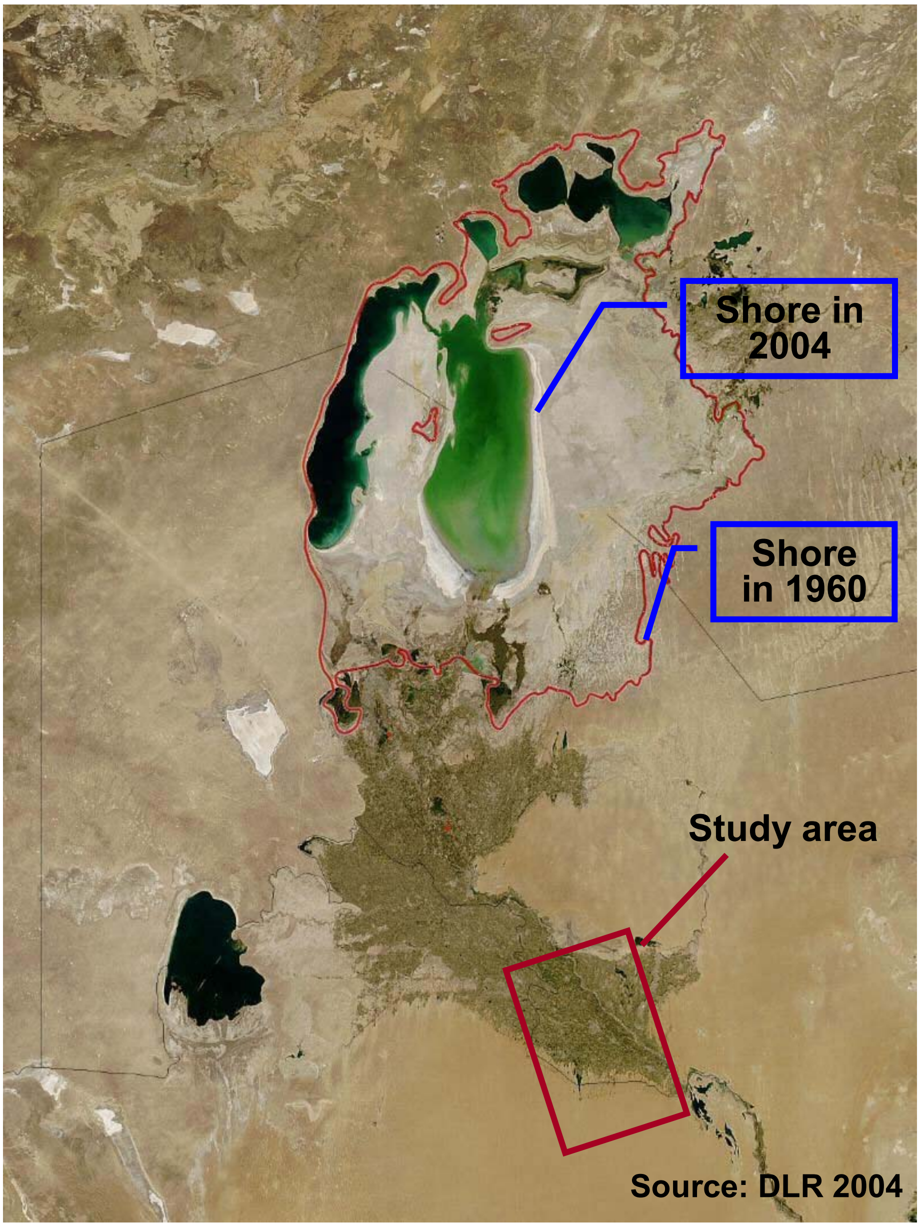

Figure 2.1 Location of study area

The lake has lost 80% of its volume and more than 50% of its surface (Hoffmann, 1997) and is still shrinking. Today, both feeder rivers seep away before reaching the former forth-largest inland water body on earth. The increasingly frequent storms triggered off by the changed regional climate blow out and deposit salty toxic dust over hundreds of kilometers causing secondary damage (Usmanova, 2003).

The ecologically worst affected regions are situated south of the lake, namely Karakalpakstan and Khorezm. Prevailing irrigation schemes, heavy use of fertilizers and other agricultural chemicals (including pesticides and defoliants) as well as agricultural practices like leaching have led to the degradation of water and soil (Glantz, 2002).

In the recent past, a number of national, regional and international programs to mitigate the effects of the Aral Sea disaster were launched. A major program is considered to be the Aral Sea Basin Program (ASBP), a result of interstate agreements. The World Bank, UNDP, UNEP and UNESCO are involved in its coordination and GEF activities closely linked to it. Others are, e.g., the Rural Water Supply Program (RWSP), Technical Assistance for the Central Independent States (TACIS) and the Water Resources Managment and Agricultural Production in the Central Asia (WARMAP). The objectives of these internationally funded programs can be summarized as follows: improvement of water management, stabilizing the environment, improvement of socio-economic conditions, improvement of water management and agriculture, strengthening of regional institutions and capacity building in the Aral Sea area (SIWI, 2000). In 1999, the advisory board of the ASBP and UNESCO released the 'Water Related Vision for the Aral Sea Basin' and emphasized that this is a man-made situation that can be also 'man mitigated' by adoption of sustainable management strategies.

In 1997, the World Bank approved a US$ 75 million loan for the 'Water Supply, Sanitation and Health Project', which is co-funded by the German Bank for Reconstruction (KFW) and the Kuwait fund. The aim of the project was to improve health of the rural population in Karakalpakstan and Khorezm. In general, these projects focused on the drinking water infrastructure and neglected sanitation. USAID funded upgrading of the Drinking Water Treatment Facility in Pitnyak (Khorezm) and the German Red Cross a reverse osmosis plant in Takhtakupyr (Karakalpakstan). Other small-scale projects dealing with health are donated by NGO's and humanitarian aid organizations.

2.3 Demographic characteristics

Uzbekistan is the most populous country in Central Asia. The vast majority of the population are Uzbek (80%). Other ethnic groups are Russians (5.5%), Tajiks (5%), Kazakhs (3%), Karakalpaks (2.5%), Tatars (1.5%) and others (2.5%). The state language is Uzbek, but Russian is widely used as the *lingua franca* in urban centers and in business affairs. About 88% of the population are Muslim, 9% Eastern Orthodox and 3% have other religious affiliations.

Similar to other CAR, the demographic profile of Uzbekistan has changed since 1991. Total population numbers increased from 20.6 million in 1991 to 25.5 million in 2003 (+ 23.7%). Although the natural population growth per 1,000 population has declined from 28.8 in 1991 to 15.7 in 2002, the country still has a rapidly growing population (Figure 2.2) due to high fertility rates and low total mortality. The total fertility rate decreased from 4.1 in 1991 to 2.4 in 2003, in the context of 35.1 live births per 1,000 population in 1991, compared with 19.9 in 2003.

The relatively low crude death rate decreased further from 6.3 to 5.4 between 1991 and 2002. One of the consequences is that Uzbekistan has a young population: inhabitants under 15 years of age amount to 36% and those over 65 only to 4%. Approximately 63% of the Uzbek population resides in rural areas. The overall population density is 57 individuals/km^2 (WHO, 2006). Population density varies substantially between different regions. Owing to a high proportion of uninhabitable areas, the population clusters in the urban areas and fertile river valleys.

Demographic numbers for Khorezm *viloyat* show similar tendencies, but the population growth is still faster and the rural population share is bigger than for Uzbekistan as a whole. The total population of Khorezm was 1.1 million in 1991 and almost 1.4 million in 2002. In the period between 1991 and 2001, the crude birth rate and crude mortality rate for the Khorezm region decreased from 71 to 45 and from 6.3 to 5.4 per 1,000 population, respectively. The natural population growth rate declined during this period from 30 to 17.4 per 1,000 population (Figure 2.2).

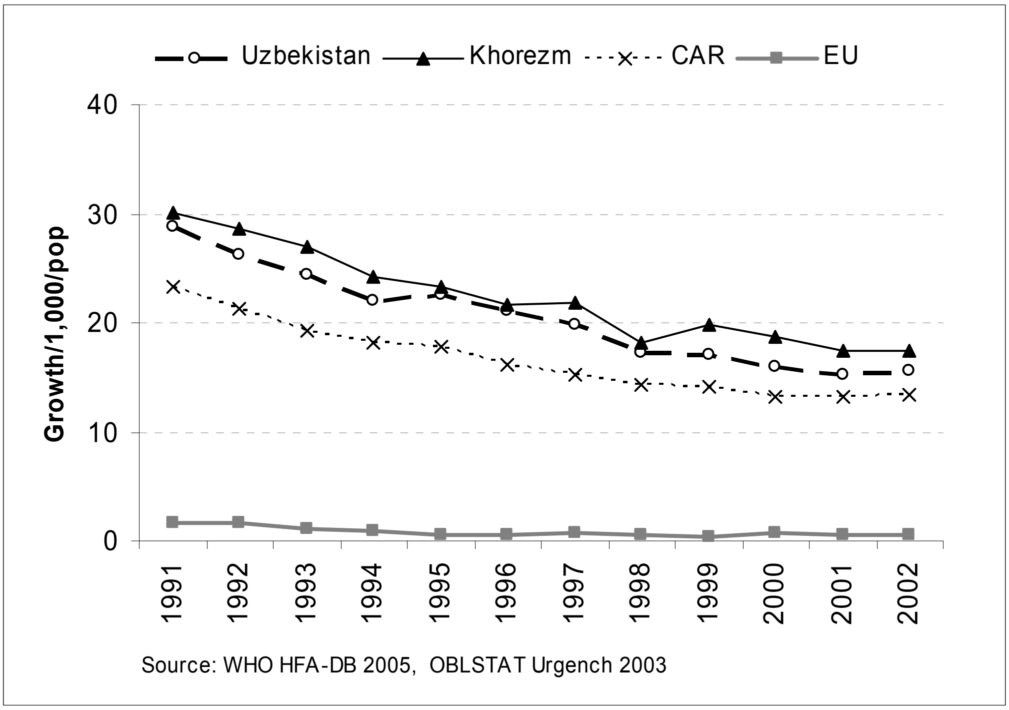

Figure 2.2 Natural population growth between 1991 and 2002

According to results from the random sample of the present study, individuals under 15 years formed 34% and those older than 60 about 4% of the population. The rural population in Khorezm has increased from 63.6% in 1991 to 67.1% in 2001. With 221 individuals/km^2 Khorezm belongs to the densely and the neighboring Karakalpakstan to the sparsely populated areas (8 individuals/km^2).

2.4 Health status and health care

2.4.1 Health indicators and prevalent diseases

The health status of the Uzbekistan population is outlined using mainly the following indicators: life expectancy at birth, infant mortality and under-five mortality rate. The life expectancy at birth in Uzbekistan rose at the end of the 1980s and slumped again in the beginning of the 1990s. This decline was halted in 1994 and then increased again to a life expectancy of 70 years in 2002 (male 67.6, female 72.5), which is about one year higher than the CAR average, but eight years less than the EU average (WHO, 2006).

Between 1992 and 2001, the under-five mortality rate dropped from 37.4 to 18.3 deaths per 1,000 children (UNICEF, 2003). According to UDHS results, the under-five mortality rate estimate was 59.3 deaths per 1,000 children for the mid-1990s.

Since 1992, the infant mortality rate has been steadily falling – from 35.1 to 16.6 deaths per 1,000 infants – being the lowest in the CAR region in 2002 (WHO, 2006). The infant mortality rate average of the official annual rates for the mid-1980s to the mid-1990s was 37 deaths per 1,000 infants and about 16% lower than the estimate from the 'Uzbekistan Demographic and Health Survey' for the same period, which was 46 deaths per 1,000 infants. For the period from mid-1992 to mid-1996, the infant mortality rate was estimated as 49 deaths per 1,000 infants (UDHS, 1997). The estimate from the Multiple Indicator Cluster Survey (MICS) assessed the infant mortality rate in the year 2000 to 52 deaths per 1,000 infants (UNICEF 2001) (Figure 2.3).

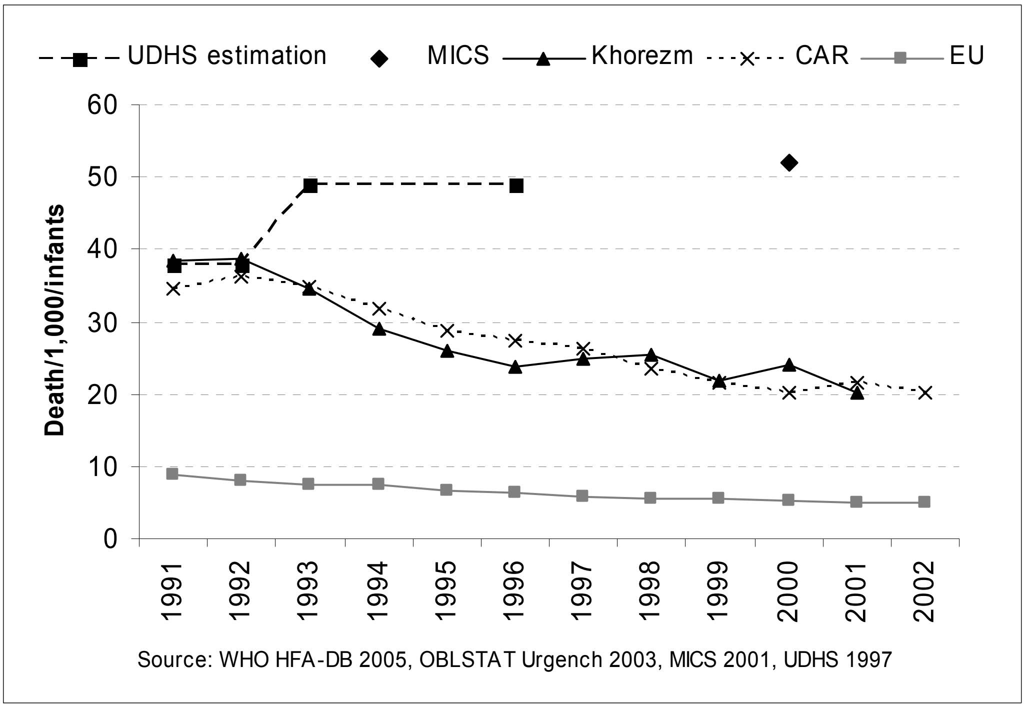

Figure 2.3 Infant mortality rates for the period between 1991 and 2002

Differences between official data and survey estimates are due to different definitions of the term 'live birth'. Recording infant deaths is still carried out according to the Soviet definition, which differs from the WHO definition in several aspects. The Soviet definition considers the presence of breath as the sole 'live birth' criterion, excluding other signs of life, and infants born before the end of the 28th week of pregnancy with a weight of under 1,000 g or a length of under 35 cm and who die during the first seven days of life (UNICEF, 2003). This makes it difficult to compare infant mortality rates between regions. Hence, adoption of the WHO definition by countries belonging to the

WHO Europe region would offer better baseline data for international comparisons. So far, WHO estimations are based on official national data being aware of the problem.

In general, the numbers for Khorezm show the same trend as the national infant mortality rate and have almost halved during the last decade (for Khorezm from 38.4 to 20.2/1,000 infants); at the same time, the stillbirth rate also decreased substantially from 14.9 to 5.2 per 1,000 live births (according to the Soviet definition).

In 2002, general morbidity data for Khorezm were provided by the Regional Department on Public Health (OBLZDRAV) in Urgench. They distinguish between new cases (registered for the first time) and repeat cases for all diseases. The numbers for the repeat registration show only a slight increase in all registered cases from 942 to 973 cases per 1,000 population between 1991 and 2001. In the same period, morbidity of new cases rose by about 26% from 415 to 524 cases per 1,000 population. Morbidity rates for new cases were the highest for two urban centers in Khorezm, i.e., Urgench city and Pitnyak city.

Widespread diseases and health-conditions in Uzbekistan are acute respiratory infections, cardiovascular diseases and anemia. Mortality due to diseases of the respiratory systems continues to show one of the highest rates in the region, although somewhat lower than in the other CAR. It is the primary cause of morbidity and the leading cause of infant mortality (80%) (UDHS, 1997). A specific problem in the Aral Sea region is the high incidence of bronchial asthma (WHO, 1998).

Cardiovascular diseases are the leading cause of death in Uzbekistan. The standardized death rate for disease of the circulatory system was 773 (CAR 766, EU region 480) and for ischemic heart disease 404 per 100,000 population in 2002 (CAR 396, EU region 223) (WHO, 2006). In Khorezm, morbidity of cardiovascular diseases fluctuated around 300 per 100,000 population between 1995 and 2000.

Anemia is an overall health problem in Uzbekistan; about 60% of Uzbek women and 61% of Uzbek children aged under three suffer from some degree of anemia (UDHS, 1997). This health condition is also aggravated in Karakalpakstan, where 65% of the young women (15 - 30 years), 62% of the middle-aged women (30 - 50 years) and 80% of the toddler age group are anemic (Morse, 1994).

2.4.2 Diarrheal diseases and viral hepatitis

According to Ministry of Health data, in 1997 about 600,000 adults and 1.2 million children suffered from infectious diseases in Uzbekistan. The most common intestinal diseases, which accounted for 70% of all infections, were: acute intestinal infections, dysentery, *Salmonella* infections and viral hepatitis (WHO, 1999).

The control over the country's infectious diseases and sanitation status is the duty of the Department of Sanitary-Epidemiological Inspection. This institution is also in charge of the supervision of the regional and local Centers of Sanitation and Epidemiology (OBLSES) which monitor for infectious diseases on the respective level.

The incidence for all acute intestinal infections on national level as well as for Khorezm and Karakalpakstan have declined substantially since independence in 1991. It dropped about 61% for Uzbekistan, 68% for Karakalpakstan and even 86% for Khorezm (Figure 2.4). However, the incidence for all acute intestinal infections in Khorezm was highest in 1991 and fell below the national average in 1999. In 1996, the UDHS found an overall diarrhea prevalence rate of 5.2% in children aged under three. For survey region 1, which comprised Karakalpakstan and Khorezm, the diarrhea prevalence was 8.3%, exceeded only by Tashkent city (9.2%) (UDHS, 1997).

Between 1992 and 1999, dysentery incidence has halved for Uzbekistan. In the decade between 1991 and 2001, dysentery incidence declined 3-fold for Karakalpakstan and even more than 10-fold for Khorezm. The shigellosis incidence for Khorezm dropped substantially from 12.1 to 0.6 per 100,000 population between 1997 and 2000. While the incidence rates for urban and rural population were similar in 1997, since 1998 the incidence rate has been significantly lower for the urban population than for the rural population. The incidence for typhoid fever has decreased for Uzbekistan from 7 to 1 per 100,000 population since 1991. In the same period for both regions, Khorezm and Karakalpakstan, the incidences were lower than the nation average except in the year 1991 (Herbst et al., 2003).

At the beginning of the 1990s, incidence of viral hepatitis (all forms) in Uzbekistan was the highest in the European region (WHO, 1999).

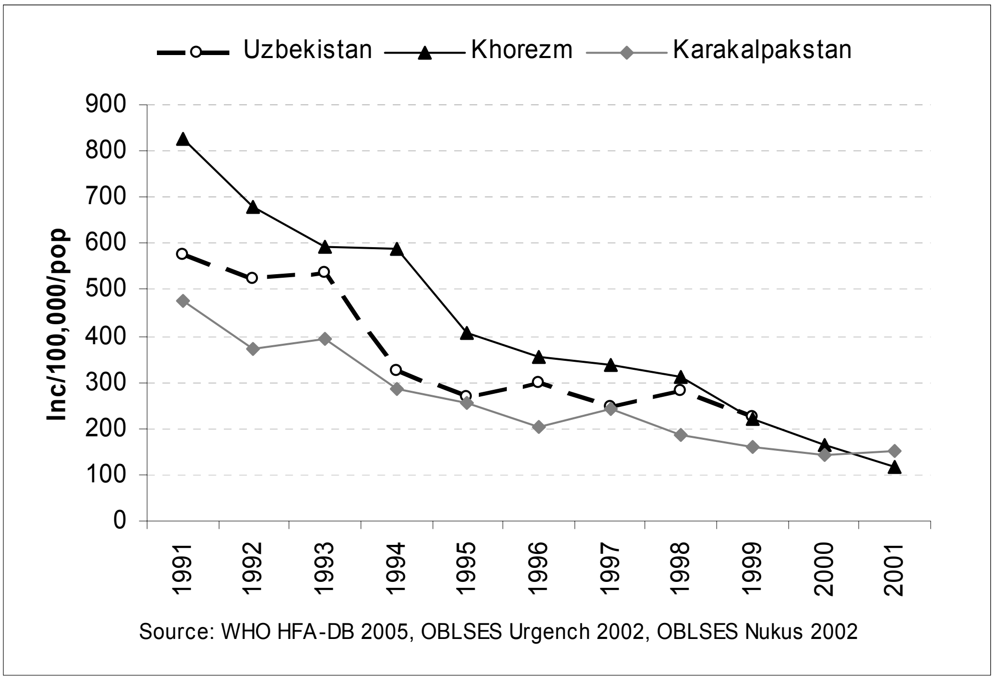

Figure 2.4 Acute intestinal infections incidences between 1991 and 2001

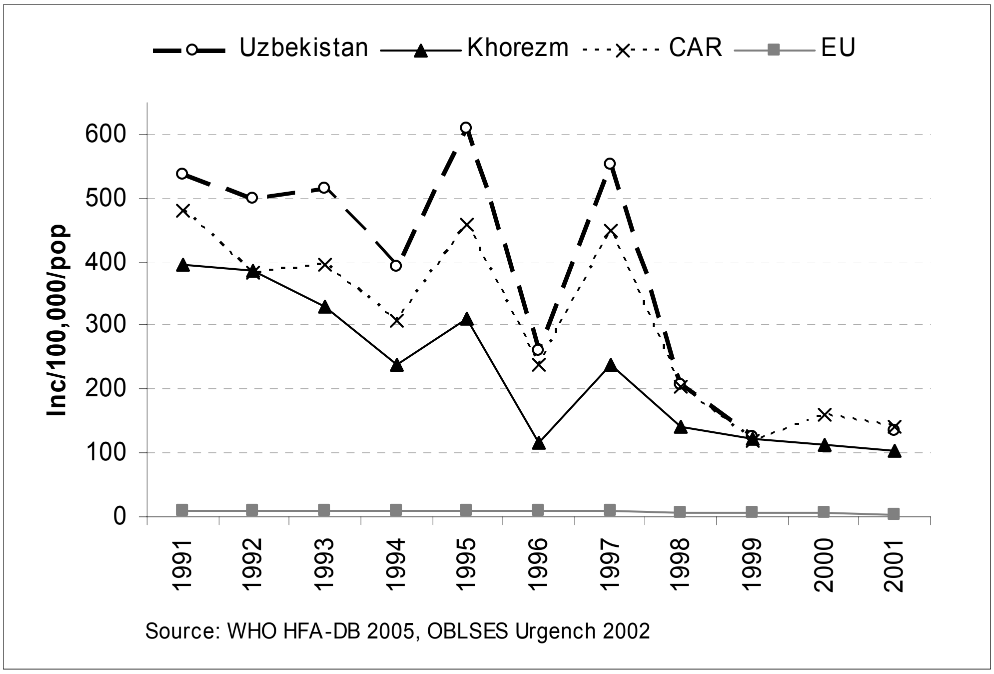

Figure 2.5 Hepatitis A incidences between 1991 and 2001

Figure 2.5 clearly shows viral hepatitis A cycles and the overall decrease of its incidence rates for Uzbekistan, Khorezm, Karakalpakstan, CAR but not the EU. It is noteworthy that average incidences for Uzbekistan exceeded those for CAR, but incidences for Khorezm and Karakalpakstan ranged considerably below the CAR average for most of the time. Since 1999, the overall downwards trend was stopped and now incidence rates fluctuate more or less on a similar level. The cumulative incidence for viral hepatitis A in Khorezm declined between 1991 and 2001 from 395 cases to 103 cases per 100,000 population, and the rural exceeded the urban incidences by more than 50% in 1999 and 2000.

2.4.3 Health care system

Uzbekistan's health care system provides universal coverage and is currently in the process of decentralization. Its main source of financing is the state budget derived from trade and taxation, and it was one of the areas most severely affected by the post-independent economic recession. Regarding the total health expenditure as per cent of gross domestic product (GDP), it is striking that the figure has more than halved from 5.9 to 2.4% between 1991 and 2003. Measured by the purchasing power parity conversation factor per capita (ppp US$), total health expenditures show an even steeper decline. In 1991, the total health expenditure was 165 ppp US$ per capita, whereas it was only 40 ppp US$ per capita in 2002. As a consequence, in-patient care admissions in Uzbekistan have decreased by about 41% from 24 to 14.2 consultations/100 population per year since independence (Figure 2.6) (WHO, 2006). Outpatient medicine and pharmaceuticals have been excluded from the state benefit package, and it is suspected that formal and informal out-of-pocket payments account for the most of the health care expenditures (WHO, 1999).

A study in Kyrgyzstan has proven a similar health-economic development and concluded that patients' consultations have decreased significantly because the patients were charged for the treatment. This tendency is even more valid for rural and poor residents. "Those from the poorest group are less likely to seek help from the medical services..." (Falkingham, 1998/1999).

These facts may help to understand the decreasing incidences of waterborne diseases in general and the changing share of urban and rural incidences. Because the poor rural population can no longer afford medical treatment, their diseases are less frequently registered. This may also explain the increase in the registration of cardiovascular diseases. Because these diseases are more threatening to adults, one can assume that they are more willing to pay for treatment of a heart attack than for a diarrhea episode.

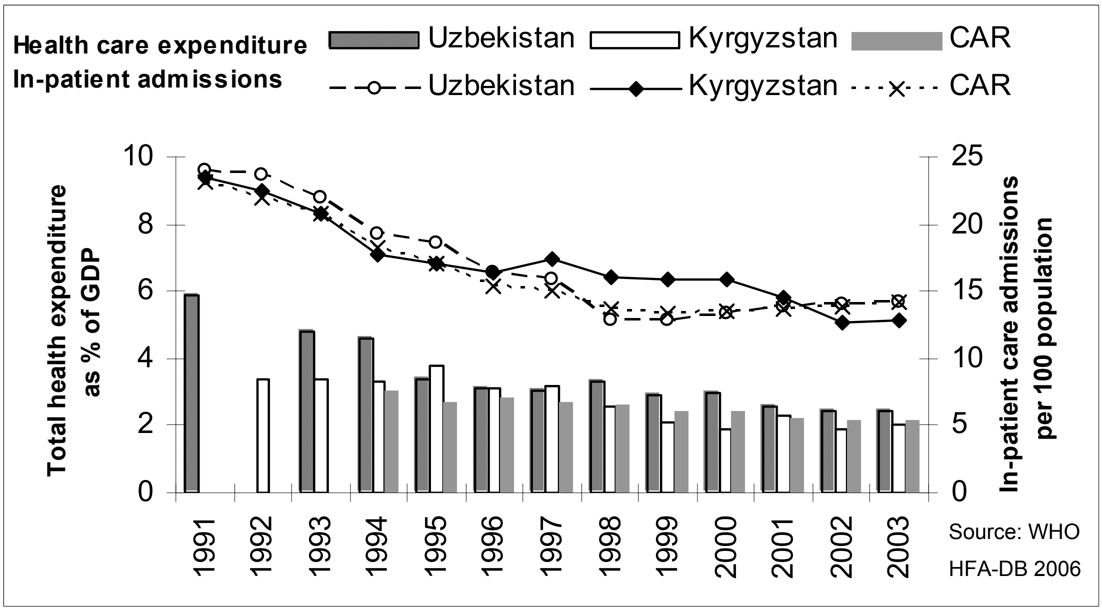

Figure 2.6 Decline of health care expenditures in Central Asia

2.5 Drinking water supply and sanitation infrastructure

A total of 53% of the Uzbek population is connected to a water supply system, but there are substantial differences between urban (85%) and rural regions (33%) (WHO, 2006). According to official data, 66% of the people living in Khorezm have access to piped water, and 98% of the urban and 62% of the rural population are connected to a public water supply system (Khorezm Regional Department on Public Health, 2000). However, considering data from field studies, only 8% of the rural population are connected to a water supply system (Oldham et al., 1999).

Since 1991, the Pitnyak Drinking Water Treatment Facility (Tuyamuyun Urgench) is the main drinking water producer in the region. The facility was upgraded in 1995 by USAID donations. The plant draws surface water from the Amu Darya (30.000 - 35.000 m^3/day) and since 2001 from the Kaparas reservoir (120.000 m^3/day) (Personal communication of the Pitnyak Drinking Water Treatment Plant, March 2002). The drinking water treatment includes: radial sedimentation, horizontal sedimentation and sand filtration. Before the water enters the storage reservoirs, fluid chlorine (Cl^2) is added.

In the Khorezm region, the urban and rural drinking water supply is served by different institutions. Khorzem Agrovodokanal serves the rural regions of the *viloyat*. The drinking water for urban areas is mainly distributed by 3 water suppliers: SUVOQAVA, OBI HAYOT and Tuyamuyun Urgench VV (Khorezm Vodokanal). Most of the drinking water distributed by these companies is purchased from the Drinking Water Treatment Facility in Pitnyak. Before distribution, the drinking water passes a reservoir in Urgench, where it is checked for chlorine residuals and additional chlorine is added if necessary (free residuals < 1.2 mg/L).

Being connected to the drinking water supply does not necessarily mean continuous supply. The reasons are: low pressure in the distribution system, leakages and arbitrary measures, e.g., shut off to reduce fuel consumption of pumping stations. Whereas drinking water is mostly pumped to the urban areas all day, rural areas are usually served from 6.00 - 9.00 a.m., 12.00 - 2.00 p.m. and 6.00 - 9.00 p.m. Besides drinking water quantity problems, these practices raise quality concerns, because leakages and insufficient water pressure in the mains and drinking water pipes allow cross-contamination by sewage from the sewerage pipes located alongside the drinking water system.

The main drinking water sources in rural areas are groundwater and shallow groundwater. Here, mostly hand pumps are used for the abstraction of groundwater from tube wells (63%). Other water sources for household needs are open wells (28%) and untreated surface waters like springs, rivers or ponds (1%) (Oldham et al., 1999). In Uzbekistan, 57% of the population have access to a sewage system, septic tank or other hygienic means of sewage disposal. In urban and in rural areas, those with access amount to 73% and to 48% of the population, respectively. The overall numbers for Khorezm range between 6.7% (Khorezm Regional Department on Public Health, 2000) and 23% (Personal communication OBLSTAT, March 2002), according to the source. The OBLZDRAV estimate assesses that 39% of the population living in the towns Urgench, Pitnyak and Khiva versus 1.7% of the rural population have access to sanitation. Roughly 9% of the households are connected to a sewage discharge without treatment. This means that the sewage is directly discharged into surface waters, which are used for irrigation or even drinking water purposes.

SUVOQAVA, which supplies drinking water for the urban area of Urgench, is also responsible for the elimination of the waste water. The Urgench facility was established as a pilot project and has not been upgraded since the 1970s. The sewage treatment comprises the following steps: grid chamber, horizontal sedimentation, a biological phase using oxygen, a chemical phase using activated sludge, which comprises the reduction of nitrates and phosphates, and a final chlorination. However, during an inspection of the treatment plant by the author, its efficacy was assessed very low. This statement is based on the fact that the sewage entered the treatment plant as a black and viscous fluid and was still dark gray at the effluent.

2.6 Microbiological drinking water quality

In Uzbekistan, drinking water sampling and processing is carried out according to the standardized Russian methods (State Committee for Standardization, 1984) by the OBLSES. Thus, drinking water in the public supply network is monitored for total microbial count (TMC), coli index and coli titer. The parameter TMC is comparable with the heterotrophic plate count (HPC) at 36°C, the limit in Uzbekistan (like the one prescribed by the German Drinking Water Regulation) is 100 colony forming units per milliliter (CFU/mL).

The procedure conducted to obtain the coli index is a semi-quantitative method to determine the number of coli bacteria, similar to the most probable number (MPN) method. The coli index is a statistical approximation, which expresses the most likely number of coli bacteria contained in one liter of drinking water. To give an example: this means that in one liter of drinking water with a coli index of 3 between 0.5 and 13 coli bacteria can be present (Daubner, 1984). The coli titer is the amount of water that is likely to contain 1 coli bacterium; it is calculated on the basis of the respective coli index result. According to the standards of the State Committee for Standardization (GOST 2874–82), the critical limits are 3 and 333, respectively. The microbiological drinking water quality is monitored increasingly infrequently by the respective local OBLSES for each *tuman*.

According to the records for the period between 1991 and 2001 – kept by the OBLSES in Urgench – in the Urgench tu*man* most (57%) of the drinking water samples were taken from the drinking water supply system in Urgench city. Sampling in the rural area of the Urgench *tuman* or other drinking water sources was only sporadic. Regarding the results of the drinking water montoring, two aspects were striking. First, the number of samples have decreased about by 78% during the past decade. Second, the microbiological quality of the drinking water has deteriorated dramatically. Especially since the beginning of the drought, more than 30% of the samples – in 1999 even 62% percent of the drinking water samples – contained more than 100/CFU of TMC bacteria. The results of the fecal contamination monitoring are even worse: coli index and coli titer also peaked in 1999. In that year, over 80% of the drinking water samples contained more than 3 coli bacteria per liter. In total, in 9 out of 11 years, more than 50% of the samples contained more than 3 coli bacteria per liter (Table 2.1).

The comparison of the microbiological drinking water sampling shows differing trends for microbiological drinking water quality in Khorezm and in Karakalpakstan. While the number of samples exceeding the critical limit for TMC has clearly been increasing in Khorezm, it has continuously been decreasing in Karakalpakstan. Regarding fecal indicators, water quality in Khorezm has deteriorated dramatically since 1999. In Karakalpakstan however, the quality has improved, since 1997. For the 5-year period between 1997 and 2001, 65% of the samples in Khorezm and 30% in Karakalpakstan had a coli index > 3 (Herbst et al., 2003).

Table 2.1 Microbiological drinking water quality in Khorezm (1991 – 2001)

Microbiologial drinking water quality							
		TMC >100		Coli index >3		Colititer <333	
Year	No. of samples	No.	%	No.	%	No.	%
1991	366	70	19	208	57	207	57
1992	212	34	16	139	66	139	66
1993	221	53	24	175	79	175	79
1994	133	4	3	97	73	98	74
1995	167	13	8	96	57	96	57
1996	163	14	9	99	61	99	61
1997	147	20	14	70	48	70	48
1998	121	26	21	49	40	50	41
1999	204	126	62	173	85	170	83
2000	79	29	37	63	80	63	80
2001	82	40	49	59	72	57	70
Σ	1895	429	23	1228	65	1224	65

3 MONITORING OF DRINKING WATER QUALITY

3.1 Introduction

Already in ancient Greece and Egypt, the public health relevance of drinking water was considered. Texts dating back 6,000 years describe simple drinking water treatment technologies like boiling, filtering, straining and exposure to sunlight (UV radiation). About 4,000 years later, the Romans designed well maintained drinking water distribution systems (WHO, 2003). This knowledge was neglected for centuries until devastating waterborne epidemics, like the cholera epidemics in the 19th century, called for action. Since then, drinking water treatment and quality monitoring, especially for fecal indicators, has been continuously improved.

Nowadays, according to the WHO Guidelines for Drinking Water Quality (GDWQ), operational monitoring parameters for source waters include turbidity, color, conductivity and meteorological events. Parameters to be monitored for treatment and piped distribution systems are: turbidity, color, chlorine residuals, fecal indicator bacteria and HPC.

In developing countries, the magnitude of fecal pollution of drinking water and the incidence of waterborne disease is much higher than in industrialized countries (Ashbolt et al., 2001; Cotruvo and Trevant, 2000; Moe, 2002; WHO, 2004), especially in rural water supplies (Moe, 2002; WHO, 2004). Since independence in Uzbekistan, operation and maintenance investments into piped drinking water distribution systems have been rare. Well established drinking water monitoring structures and infectious disease surveillance during the Soviet period deteriorated due to the financial problems after independence in 1991.

The 3-month monitoring of different drinking water sources utilized by the households enrolled in this study created a baseline of knowledge on selected microbiological and physico-chemical parameters. Drinking water monitoring results facilitated a general assessment of the drinking water quality and its impact on public health, which led to recommendations regarding further research projects on water-related health and measures to improve drinking water safety. Microbiological drinking water monitoring data also facilitated an advanced interpretation of the outcomes of the diarrhea survey.

3.2 Methodological considerations on drinking water monitoring

Recommendations, feasibility of methods under field conditions, technical possibilities and the project budget were taken into account when selecting the methods to be applied for drinking water monitoring. According to the WHO GDWQ, the best fecal indicators are *Escherichia coli* (*E. coli*) and thermotolerant coliforms processed using membrane filtration (WHO, 2004). The specific detection of *E. coli* is time and resource consuming. Cultivation of thermotolerant coliforms is restricted to incubation temperatures of 44 - 45°C (WHO, 2004). Another recommended method to prove fecal contamination is the multiple-tube method. It is a semi-quantitative test to determine the most probable number of coliform bacteria (Carlson, 2002; WHO, 1997). Because of the large number of tubes involved, the method is also very time and resource consuming.

In order to ensure quality standards for all cultivation methods, facilities for preparation and storage of specific nutrient agars and sufficient sterilization equipment have to be present. A major precondition for the microbiological sample processing according to quality standards is a clean laboratory environment. This includes a clean environment for the storage and handling of materials needed as well as for the processing of the samples.

Costs and time needed to establish facilities offering hygienic safety and different incubation temperatures conflicted with the number of samples being processed. Having reflected these facts, the best way to ensure hygienically safe conditions was to process the samples under laminar air flow conditions with disposal material that was able to withstand at least six months of non-cooled storage under high temperatures. It was therefore decided to use sterile ready-to-use nutrient sets and to modify membrane filtration according to field conditions. The accuracy of the field method, which will be referred to as method 1, was tested in a laboratory experiment (see 3.3.1). Under the given circumstances, which restricted the choice of indicator parameters substantially, HPC, fecal coliforms and enterococci – incubated at 37°C – were selected as parameters for the microbiological monitoring of drinking water. Due to growth performance of coliform bacteria and enterococci, under field conditions counts after 48 ± 4 h of incubation are regarded as most reliable (see 3.3.1).

Interpretation of microbiological field data requires an understanding of the physical and chemical environment sampled. Therefore, on-site physico-chemical and organoleptic parameters such as temperature, odor, pH, color, turbidity and oxygen were determined.

The semi-quantitative method selected for measurement of the nitrate and nitrite concentration was chosen taking into account field conditions and time restrictions. Therefore, easy-to-use test sticks were used. Expected levels in drinking water sources fell into the detection range of the test stick (nitrate 10 - 500 mg/L, nitrite 1 - 80 mg/L).

Microbiological results were stored in a MS Office Access 2000® data base. Statistical analysis of water monitoring data was carried out using MS Office Excel 2000® and SPSS 12®.

3.3 Microbiological drinking water quality

3.3.1 Methods

Control experiment

The control experiment was conducted for the evaluation of the field processing method 1. In this laboratory experiment, fecal indicator bacteria growth and growth of heterotrophic bacteria of method 1 were compared with standard methods, which will be referred to as method 2. Field conditions were simulated and samples were processed in parallel. Three prepared solutions containing different species and quantities of bacteria served as samples. Solution A contained enterococci and *E. coli*, solution B contained *Citrobacter freundii* and solution AB contained enterococci, *E. coli* and *C. freundii*.

Method 1 applied three types of nutrient pad sets (Table 3.1). The nutrient pads were soaked with 1.5 mL sterile distilled water and a membrane filter placed on the surface of the pad. A 1-mL sample pipetted onto the middle of the membrane filter was spread thoroughly over the filter with a sterile Drygalski spatula until the entire sample was soaked through the membrane filter.

Coliform bacteria cultivated on Endo nutrient pads were incubated at 37°C for 24 - 48 ± 4 h. Colony forming units were counted twice, after 24 h and after 48 h.

Sharply contoured dark red Colony Forming Units (CFU) were evaluated as coliform bacteria, more than 130 CFU per mL were classified as not countable.

Enterococci were cultivated on Azide-agar nutrient pads. Samples were incubated at 37°C for 24 - 48 ± 4 h. Plates were examined and counted after 24 h and after 48 h. Small red or reddish brown colonies with smooth periphery were classified as enterococci; more than 130 CFU were classified as not countable.

Heterotrophic bacteria were cultivated on standard-agar nutrient pads. Samples were incubated at 37°C for 48 ± 4 h. All visible CFU of various forms and colors were evaluated; more than 130 CFU were classified as not countable.

Method 2 was processed according to the ISO standards and the German Drinking Water Regulation (1975). For cultivation of heterotrophic bacteria, the pour plate technique was applied. One milliliter of each sample solution was pipetted into an empty, sterile Petri dish. Then 15 - 20 mL of molten nutrient-agar was poured into the Petri dish, which was then covered with a lid. The sample was mixed by rapid, but gentle clockwise and anti-clockwise movements for approximately 10 seconds. After the sample had solidified, the Petri dish was incubated in an inverted position at 37°C for 48 ± 4 h. CFU were counted using 6 to 8-fold magnification.

Fecal coliforms and enterococci were cultivated using the spread plate technique. Petri dishes with selective agar were prepared and slightly dried before use (Table 3.1). Each Petri dish was inoculated with a 1-mL sample, which was spread over the surface with a sterile Drygalski spatula. Dishes were dried until the sample had completely soaked into the agar, which was then incubated in a inverted position at 37°C for 24 - 48 ± 4 h. As in the field, enumeration of the CFU took place twice: after 24 h and 48 h. Sharply contoured dark red CFU and those with a greenish metallic sheen were evaluated as fecal coliforms (Endo-agar). On Kanamycine-Aesculin-Azide-agar, dark brown colonies surrounded by a brown halo were counted as enterococci.

Table 3.1 Nutrient media for cultivation of fecal indicator bacteria and HPC

	Bacteria	Nutrient name	Recommendation
Method 1	Heterotrophic	Standard	GDWR *
	Faecal coliforms	Endo	ISO 9308-1
	Faecal streptococci	Azide	Slanetz & Bartley
Method 2	Heterotrophic	DEV Nutrient-agar	GDWR *
	Faecal coliforms	Endo-agar	DIN 38411
	Faecal streptococci	Kanamycine-Aesculin-Azide-agar	76/160 EWG

* German Drinking Water Regulation 1975

Sampling

Drinking water samples were taken from 6 different types of sampling points: piped water tap inside the house or yard (11 sampling points), piped water tap outside the house or yard (8 sampling points), dug well outside the house or yard (7 sampling points), tube well inside the house or yard (12 sampling points), tube well outside the house or yard (1 sampling point) and household drinking water storage (11 sampling points) (Figure 3.2 -Figure 3.7).

The sampling points were selected from the drinking water sources of the surveyed households. In order to achieve a balanced share of samples, the number of sampling points per source was chosen such that it reflected the share of households served by the respective drinking water source. Criteria for the selection of sampling points were having at least one sampling point in each smallest administrative unit (*mahalla*) surveyed and the number of provided individuals. A minimum of 4 individuals had to be served by the sampling point.

Sampling started with 40 points, but due to increasingly frequent drinking water storage in summer the number of sampling points needed to be extended. So, for some piped water sampling points, the storage vessel was sampled in case no water from the tap was available. In total, 50 sampling points were defined and 463 samples taken (Figure 3.1 and Appendix 9.7).

In order to keep storage duration for the samples as short as possible the daily sampling route started with most remote sampling point and continued with less remote points. At the time of sampling, a bilingual (English, Uzbek) sampling record was filled in. Besides data of the on-site parameters, the record contained information on weather conditions and comments on special features (Appendix 9.6).

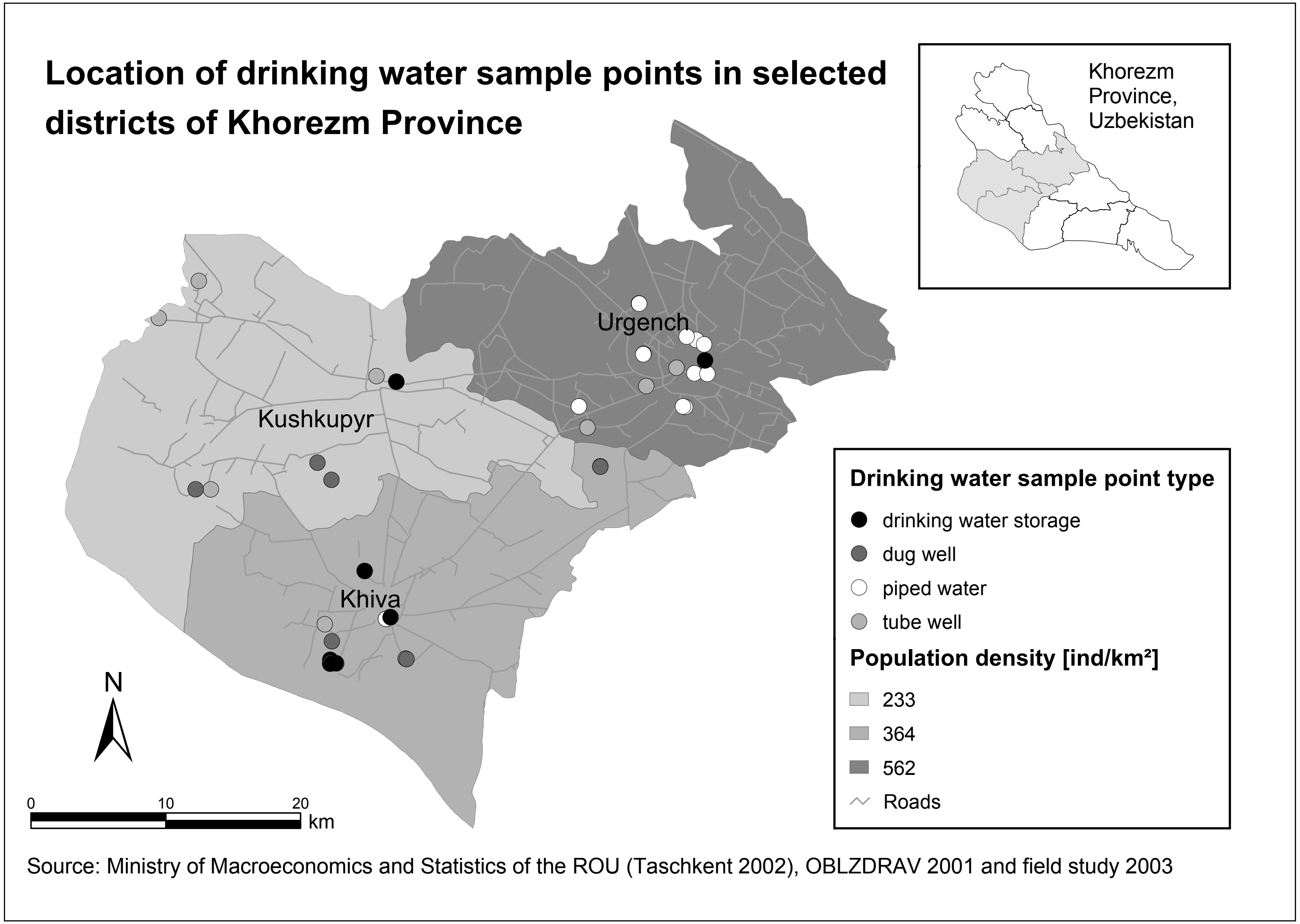

Figure 3.1 Location of drinking water sampling points

The weather conditions were classified into sunny, cloudy, changeable and rainy. Changeable was applied in case sunshine and rain alternated over very short periods.

Before taking a piped water sample, all attachments like, e.g., rubber hose and sealing tape and other extraneous matter, were removed from the tap or standpipe. The spout was disinfected by flaming with a small proprietary butane burner (Figure 3.2). If possible, the pipe was flushed for two minutes, but because of water shortages sometimes less. At one sampling point, it was impossible to remove the rubber hose, which then was flushed for two minutes.

Sampling containers were disposable pre-sterilized polystyrene containers with a volume of 150 mL. They were filled with a gentle stream of water from the tap, leaving a small air gap. Because the transport of the samples was rather short (median 4 h, range 1 - 9 h), the containers did not contain sodium thiosulfate.

Tube well samples were taken in the same manner as piped water samples after disinfection by flaming the spout of hand pumps. If the hand pump did not pump water, 1 - 2 L of water was poured into the pump for priming (initializing the needed vacuum). In 7 out of 37 cases, the respondents were asked to pour in the water he/she usually used for priming; in other cases, boiled piped water was used. The origin of the water used for priming was documented. At least two buckets of water (each 10 L) were discarded before taking the sample.

Samples from dug wells were taken by dip sampling. A small zinc container with a string attached to the handle was disinfected by flaming and dipped into the water until filled. Then, the water was poured into the sampling container.

Drinking water storage vessels were also dip sampled. The zinc dipper – for the sampling of storage containers – had a long handle and was also disinfected by flaming. The sample was poured from the dipper into the sampling container. Every sampling container was marked with the unique code of the sampling point and the date with a permanent marker. Samples were immediately transferred to dark and cool storage conditions (a portable refrigerator equipped with a holder for the sampling containers).

In the hot season, additional cool packages were placed on the bottom of the cooler to facilitate proper cooling. During transport, the temperature was measured and reported in regular intervals; median of the transport temperature was 11°C.

Samples were processed within a median duration of 4.5 hours (min. 1 - 10 h max.) after sampling.

Processing of microbiological drinking water samples was carried out using a sterile laminar flow work cabinet (Gemini 100). Samples were processed as described on Endo, Azide and standard pads. If needed, dilutions of the sample were plated out, so that the number of colonies on any of the plates fell approximately within a range of 20 and 100 CFU. Therefore, a 1-mL sample was diluted in 9 mL of sterile distilled water. Samples were incubated in a fan-assisted Heraeus (Series 6000) incubator. The beginning and termination of each incubation period was recorded in the laboratory journal. A regular quality control HPC of distilled water was performed.

After enumeration (24 and 48 ± 4 h at 37°C), Petri dishes were decontaminated pouring chlorine solution (5%) onto the bacteria colonies. Finally, the microbiological waste was destroyed in the city hospital incineration.

Figure 3.2 Flaming tap inside house

Figure 3.3 Piped water in garden

Figure 3.4 Dug well in front garden

Figure 3.5 Hand pump in front garden

Figure 3.6 Piped water standpipe on the street

Figure 3.7 Dug well with brick wall providing minimal protection

Figure 3.8 Mushrooms on brick wall of the above dug well contaminating the drinking water

3.3.2 Results

Control experiment

The comparison of method 1 and method 2 for cultivation of heterotrophic microorganisms after 48 ± 4 h at 37°C showed the same tendency for all colony counts. The median for all counts from solution A, B and AB prepared with tap water, distilled water (Aqua dest.) and distilled water with 1 g and 2.5 g/L sodium chloride – which simulates field conditions – was lower for method 1 than for method 2 (method 1 median range 18.5 - 37.5 CFU/mL, method 2 26.5 - 92.5 CFU/mL). The bacteria concentration in tap water differed only slightly between both methods. The tap water boxplot for method 2 showed the highest range in variance for the second and third quartile, in some tap water samples no bacteria growth took place (Figure 3.9). The analysis was also differentiated according to the different bacteria solutions as explained in section 3.3.1. The median for *E. coli* and enterococci (solution A) was lower for method 1 than for method 2, but ranged within the same logarithmic step. For the results for *C. freundii* (solution B) in tap water, the median concentration of bacteria differed from the other water types, being higher for method 1 than for method 2. Regarding solution B prepared with sodium chloride (1 g and 2.5 g/L), the median count of method 1 was lower than for method 2. For all counts of solution B, the medians of both methods ranged within the same logarithmic step.

The counts for fecal coliform growth in tap water, distilled water (Aqua dest.) and distilled water with 1 g and 2.5 g/L sodium chloride after 48 ± 4 h at 37°C were analyzed separately for coliform bacteria (solution A) and *C. freundii* (solution B). All median counts for coliform bacteria according to method 1 were marginally lower than for method 2 (median range method 1: 13.5 - 38.5, method 2: 15 - 40.5) (Figure 3.10). The median for the counts from solution B differed strikingly, i.e., *C. freundii* did not grow at all on the nutrient used for method 1 but for method 2, the median ranged from 0.5 - 7.5 (Figure 3.11).

The comparison of the methods regarding cultivation of enterococci from solution A after 48 ± 4 h at 37°C showed that the median for the tap water samples for method 2 (8) was marginally lower than for method 1 (10) (Figure 3.12). For all other samples prepared with distilled water (Aqua dest.) and distilled water with 1 g and 2.5 g/L sodium chloride, the median of the counts for method 2 yielded higher numbers than method 1 (median range method 1: 14.5 - 19 CFU/mL, method 2: 22.5 - 28 CFU/mL).

Results for both methods show that counts mostly ranged within the same logarithmic step. It is surprising that counts for tap water always ranged below those solutions prepared with distilled water. Later it was discovered that lower counts of tap water were due to new water pipes in the institute and increased copper concentrations, which inhibited bacterial growth.

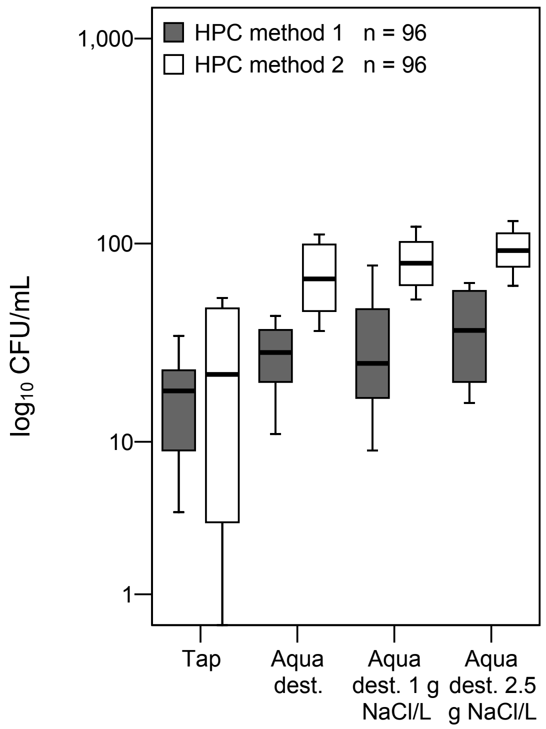

Figure 3.9 HPC of solution A, B and AB after 48 ± 4 h at 37°C

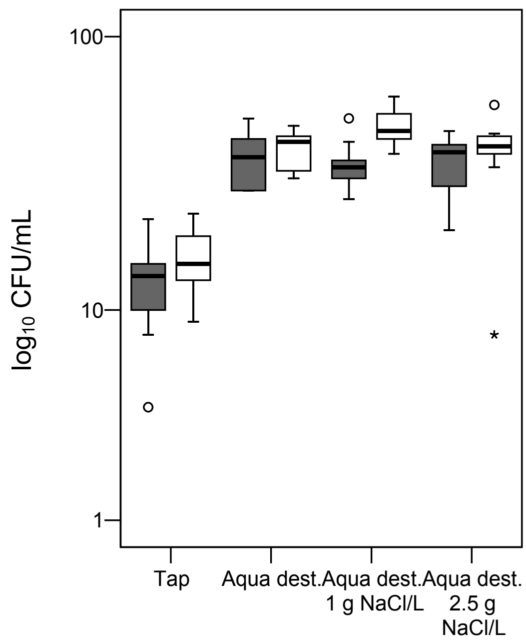

Figure 3.10 Fecal coliforms of solution A after 48 ± 4 h at 37°C

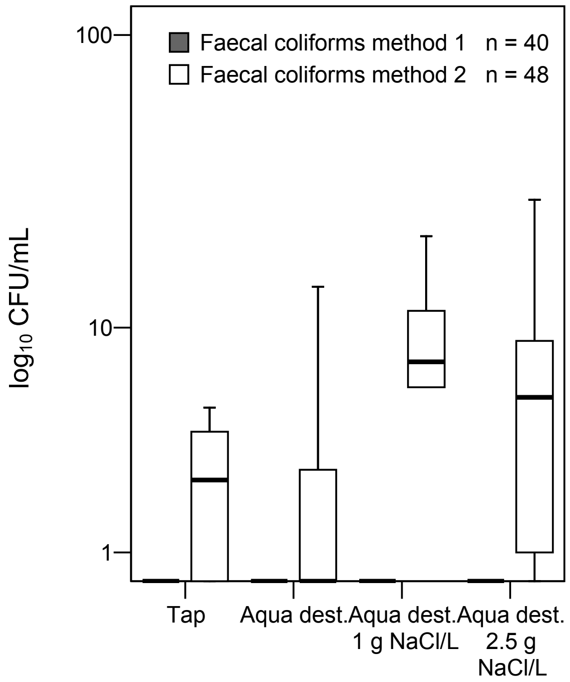

Figure 3.11 Fecal coliforms of solution B after 48 ± 4 h at 37°C

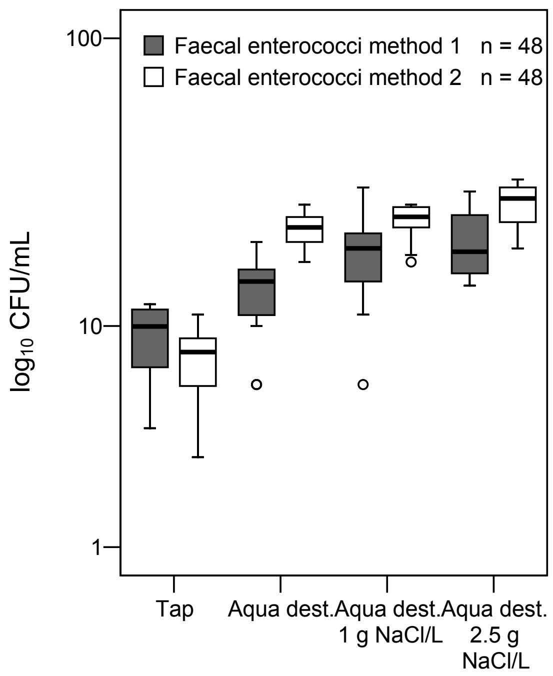

Figure 3.12 Enterococci after 48 ± 4 h at 37°C

Drinking water monitoring

In total, 463 drinking water samples were processed. In general, samples were evaluated after 24 ± 4 h and 48 ± 4 h, but due to technical problems in 62 microbiological samples, colonies were counted only once after 24 ± 4 h. As the 48 h count was used in the control experiment, samples that were counted only once after 24 ± 4 h were discarded for the comparative analysis of the count for fecal indicator bacteria. Over the entire monitoring period, greatly varying background growth was sometimes observed; this might have been suppressed fecal coliform bacteria growth.

The percentage of piped water samples per week that went beyond the critical level for fecal coliforms and enterococci is shown in Figure 3.13. Overall, samples exceeded the critical limit for enterococci more often than for fecal coliforms. The presence of all fecal indicator bacteria increased steadily over the study period. Whereas at the end of May (22nd calendar week) less than 20% of the weekly samples contained fecal bacteria, at the end of July (30th calendar week) in more than 50% of the samples fecal coliforms and in up to 100% of the piped water samples enterococci were found. Between 8% and 50% of the weekly HPC results for piped water (at 37°C for 48 ± 4 h) went beyond the critical limit.

Regarding piped water sampling points **inside the house or yard** and **outside the house or yard** the picture changes. Of all the inside sampling points 22% and 39% of the outside sampling points were contaminated by fecal coliforms. Differentiating the results of the piped water samples into **inside the house** and **in the yard or on the street,** only 13% of the inside samples, but 46% of the outside samples contained fecal coliforms. For enterococci, the trend was similar, but differences between inside and outside sampling points were less significant (Table 3.2).

Table 3.2 Proportion of piped water samples containing fecal indicator bacteria

	Proportion (%) of samples			
	Piped water inside		Piped water outside	
CFU/mL	Fecal coliforms	Enterococci	Fecal coliforms	Enterococci
0	87	69	54	52
> 0	13	31	46	48

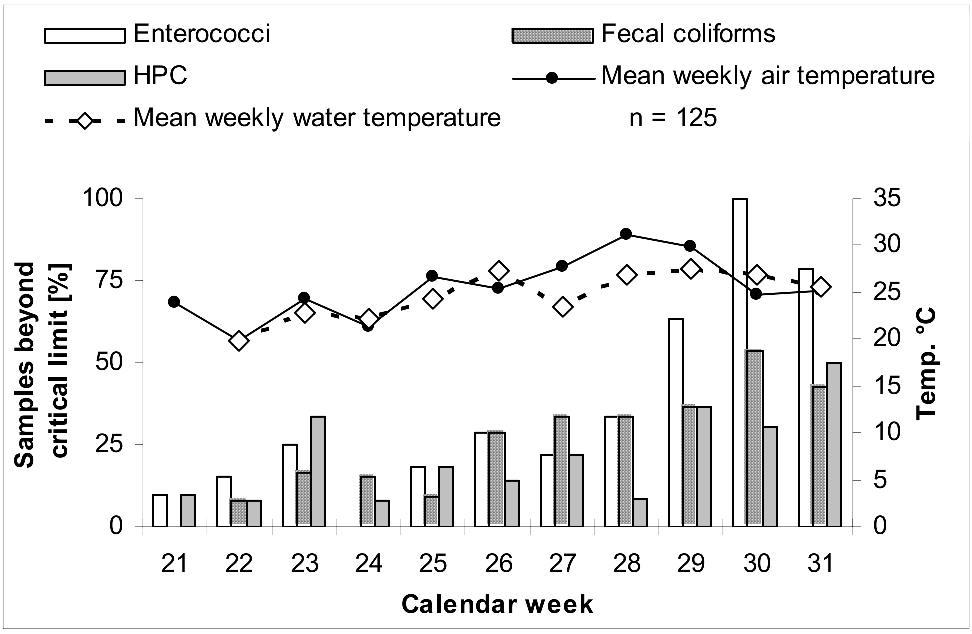

Figure 3.13 Proportion of piped water samples beyond critical levels for indicator bacteria at 37°C after 48 ± 4 h

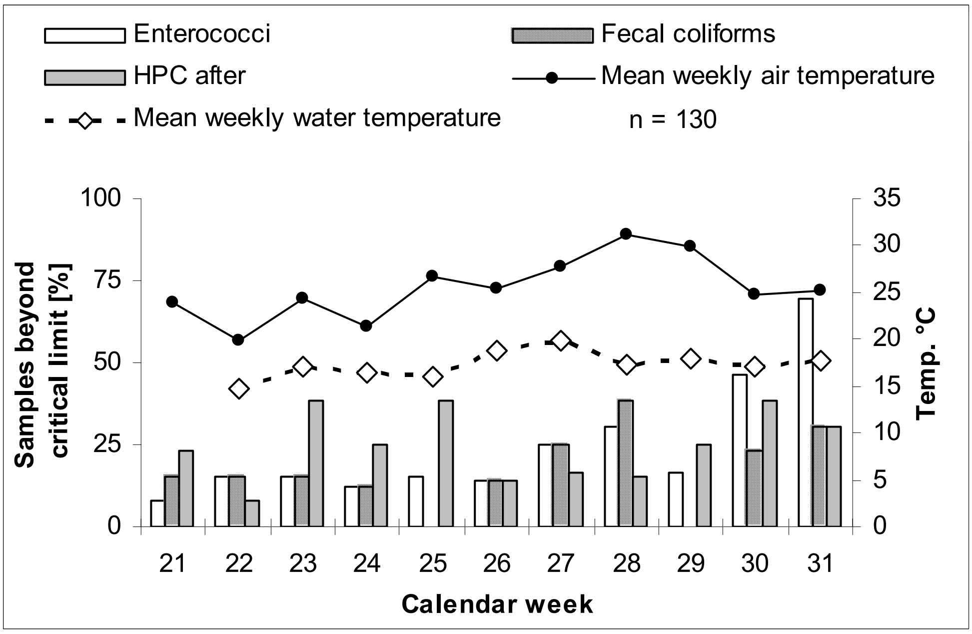

Figure 3.14 Proportion of tube well samples beyond critical levels for indicator bacteria at 37°C after 48 ± 4 h

Generally, the same trend was detected for drinking water from tube wells and pipes: a constantly increasing percentage of samples with fecal contamination between May and July. The contamination ranged up to 39% of the weekly samples for fecal coliforms and from 8% to 69% for enterococci (Figure 3.14). In drinking water from tube wells, the percentage of samples that did not meet the critical limit for HPC ranged between 8% and 39%.

Since the hand pumps of tube wells sometimes lacked vacuum, it was common practice (25% of hand pumps) to initialize the vacuum by pouring water into the pump. Water stored in an uncovered bucket next to the pump was usually used for this purpose. The percentage of tube well samples contaminated with fecal coliforms and enterococci was double that of those hand pumps that needed priming. The HPC values exceeded the critical limit in 97% of the samples taken from those tube wells (Table 3.3).

Table 3.3 Microbiological quality of tube well water

	Priming needed			
	Yes		No	
	No. of samples	%	No. of samples	%
	37		85	
FC > 0/mL	9	24	7	8
FE > 0/mL	14	38	16	19
HPC > 100/mL	36	97	65	76

8 missing, 122 valid cases

The results for drinking water samples from dug wells show a rising trend for fecal pollution over the monitoring period, but the pollution started in the first weeks at a higher level. For samples from dug wells, more than 57% of the samples always contained more than 100 CFU/mL with an increasing trend after mid July (29th calendar week). Presence of fecal coliforms after incubation for 48 h was proven for 14% to 100% of the samples per week, reaching the highest contamination rate in July. For enterococci, contamination of more than 50% of the samples was already detected at the beginning of the monitoring in May (21st calendar week), peaking in July (30th calendar week) with 100% contaminated samples per week. More than 57% of the samples always contained more than 100 CFU/mL of HPC bacteria (Figure 3.15).

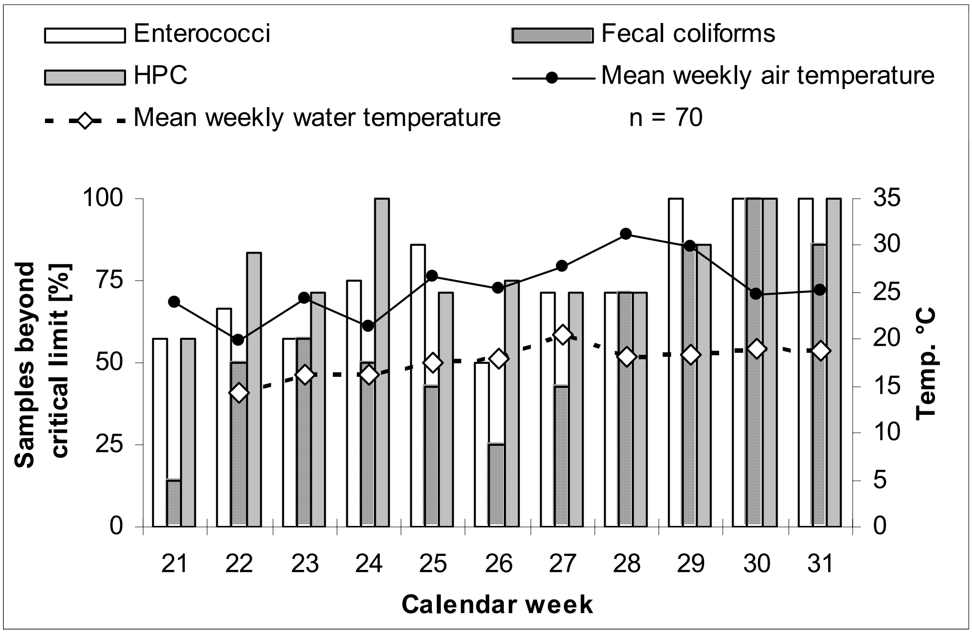

Figure 3.15 Proportion of dug well samples beyond critical levels for indicator bacteria at 37°C after 48 ± 4 h

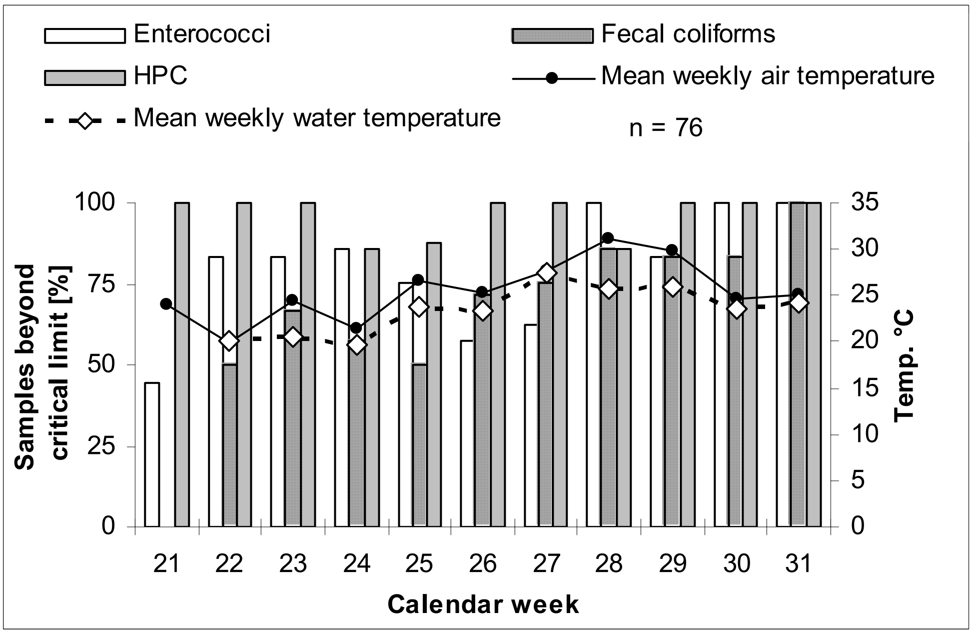

Figure 3.16 Proportion of household drinking water storage samples beyond critical levels for indicator bacteria at 37°C after 48 ± 4 h

Results for fecal coliforms and enterococci from household drinking water storage show high fecal contamination from the end of May (22nd calendar week) onwards. The enumeration of fecal coliforms detected contamination rates from 50% to 100% of the samples per week. The presence of enterococci ranged from 57% to 100% of the samples per week. Drinking water from the household drinking water storage in at least 86% of the samples exceeded the critical limit for HPC (Figure 3.16).

The microbiological quality of all drinking water sources as well as water quality at the point-of-use (POU) – tested in the storage vessels – deteriorated over the 12-week monitoring period. The worst microbiological water quality for all sampling point types was shown for July. As the air temperature during the period also increased, the Spearman correlation coefficient was used to determine the association between mean weekly air temperature, water temperature at time of sampling and weekly percentage of water samples exceeding the critical limit for microbiological indicator bacteria. Associations between air temperature and water temperature of piped water and stored water were verified on a significant level. Correlation between fecal contamination of drinking water and water temperature were high and significant. For tube well water, dug well water and water in the storage vessels statistical association could not be shown (Table 3.4). However, it is known that bacterial growth is highly dependent on the temperature of the environment.

Table 3.4 Correlation between water temperature, air temperature and microbiological indicator bacteria

	Spearman coefficient	Water temperature			
		piped water	tube well water	dug well water	storage vessel
	n = 10				
Air temperature	r	0.7	0.6	0.6	0.9
	p	0.038*	0.06	0.074	0.001**
Fecal coliforms	r	0.7	0.3	0.4	0.6
	p	0.026*	0.464	0.323	0.052
Enterococci	r	0.8	0.2	0.5	-0.04
	p	0.008**	0.602	0.154	0.905
HPC	r	0.4	-0.2	0.8	0.1
	p	0.179	0.562	0.835	0.71

* Correlation significant on 0.05 level (two-tailed)
** Correlation significant on 0.01 level (two-tailed)

In general, the level of microbiological contamination of all water sources is not acceptable if the water is used for drinking purposes. Surprisingly, tube well water was less microbiologically contaminated than piped water.

Due to the high proportion of microbiologically contaminated water samples, drinking water sources have been categorized according to the magnitude of contamination. For this reason, the proposed categories of WHO (1997) have been adapted to the microbiological methods of this study. This provides an illustration of the proportion of drinking water samples that did not meet the critical limits and the arising risk for human health. Samples from category I were free of contamination, while the samples in category II posed an intermediate to high risk to human health. From category III upwards, gross pollution posed a high to very high risk. Drinking water from piped water taps outside the house contained substantially more fecal indicators and HPC microorganisms than from taps inside the house. Samples from tube wells were contaminated less often and also to a lesser extend than samples from dug wells. They were also less often attributed to category III and IV than piped water outside the house.

Table 3.5 Classification of drinking water quality according to magnitude of contamination

		Proportion (%) of samples							
		Piped water				Tube well		Dug well	
CFU/mL	Category	inside		outside					
		FC	E	FC	E	FC	E	FC	E
0	I	87	69	54	52	82	75	41	23
1 -10	II	13	26	35	38	11	20	39	41
11 - 100	III	0	5	10	10	6	5	16	24
> 100	IV	0	0	0	0	1	1	4	11

FC = Faecal coliforms E = Enterococci

The deterioration of drinking water quality during treatment and storage in the household was also evaluated according to the magnitude of contamination. Table 3.6 shows the bacteriological water quality measured at the source and in the household storage vessels. For each source sampling point, two storage points were sampled (store 1 and store 2). It is evident that substantial deterioration occurs in all sources.

Table 3.6 Contamination magnitude in drinking water source and storage vessels

		Proportion (%) of samples																	
		Tube well 9						Tube well 12						Dug well 15					
CFU/mL	Category	source		store 1		store 2		source		store 1		store 2		source		store 1		store 2	
		FC	E	FC	E	FC	E	FC	E	FC	E	FC	E	FC	E	FC	E	FC	E
0	I	91	73	40	20	36	27	64	36	55	18	18	9	45	45	45	9	18	18
1 -10	II	9	18	10	0	27	27	18	55	18	36	45	45	36	36	9	64	45	27
11 - 100	III	0	9	40	50	36	27	18	9	27	45	18	36	18	18	45	0	27	36
> 100	IV	0	0	10	30	0	18	0	0	0	0	18	9	0	0	0	27	9	18

FC = Faecal coliforms E = Enterococci

3.4 Physico-chemical drinking water quality

3.4.1 Physico-chemical and organoleptic methods

Odor

The odor of the drinking water samples was determined by the olfactory sense of the sampler in the field. For that purpose, a glass tumbler with 1 L volume was filled with water and the odor was determined by smelling. The intensity of the smell was categorized as weak, medium or strong. The type of odor was attributed to no odor, fecal, soil, chlorine and others.

Turbidity

The turbidity of drinking water was assessed visually in the field. A glass tumbler with 1 L volume was filled with water and turbidity was assigned to the categories: clear, weak turbid, medium turbid or strong turbid.

Color

Qualitative visual assessment of the water color was carried out in the field. A glass tumbler with one liter volume was filled and held in front of white paper and the color was determined.

Determination of water temperature

A calibrated mercury thermometer was used for measuring the water temperature of each sample.

Determination of nitrate and nitrite

Nitrate and nitrite levels were determined with the help of a test stick. The Quantofix® nitrate test stick produced by Macherey-Nagel was dipped into the sample. After 30 seconds, the stick was compared with the scale of standard colors and the amount of nitrate was visually judged. The stick facilitated the determination of a nitrate level ranging from 10 - 500 mg/L and for a nitrite level from 1 - 80 mg/L. In case nitrite was present, it was determined first with the same method as the nitrate and then destroyed by amidosulferic acid (H_3NO_3S). Afterwards, the nitrate was determined with a second test stick.

Determination of free chlorine residuals

Free residual chlorine was determined by the colorimetric method using a Lovibond 2000® comparator. In a cuvette filled with 10 mL of drinking water, a Diethyl Paraphylene Diamine 1 (DPD 1) tablet was dissolved. The color of the sample was judged visually against the scale of standard colors related to specific DPD concentrations in the comparator. The comparator facilitated determination of chlorine residuals within a range from 0.2 to 4 mg/L.

Determination of other physico-chemical parameters

<table>
<tr><td>pH</td><td rowspan="4">Were determined using the
Multi measuring probe S/N 70941
produced by Consort Eijkelkamp</td></tr>
<tr><td>Salinity</td></tr>
<tr><td>Electric conductivity</td></tr>
<tr><td>Oxygen</td></tr>
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3.4.2 Results

Weather conditions during drinking water sampling

The majority of the samples (70%) was taken in sunny weather. Under cloudy and changeable weather conditions 13% of the samples were collected, respectively. In 4% of the samples the weather was rainy during sampling. The average air temperature ranged between 19.8°C in May and 31.1°C in July (Figure 3.17).

Odor

The evaluation of the odor results show that in the vast majority (94%) of the samples no odor was detected. An odor of: soil 3%, chlorine 1.5%, feces 1% and others 0.5% was recognized in 6% of samples from various drinking water sampling points. A smell of chlorine was detected in some piped water samples taken from tap sampling points 33, 38 and 40.

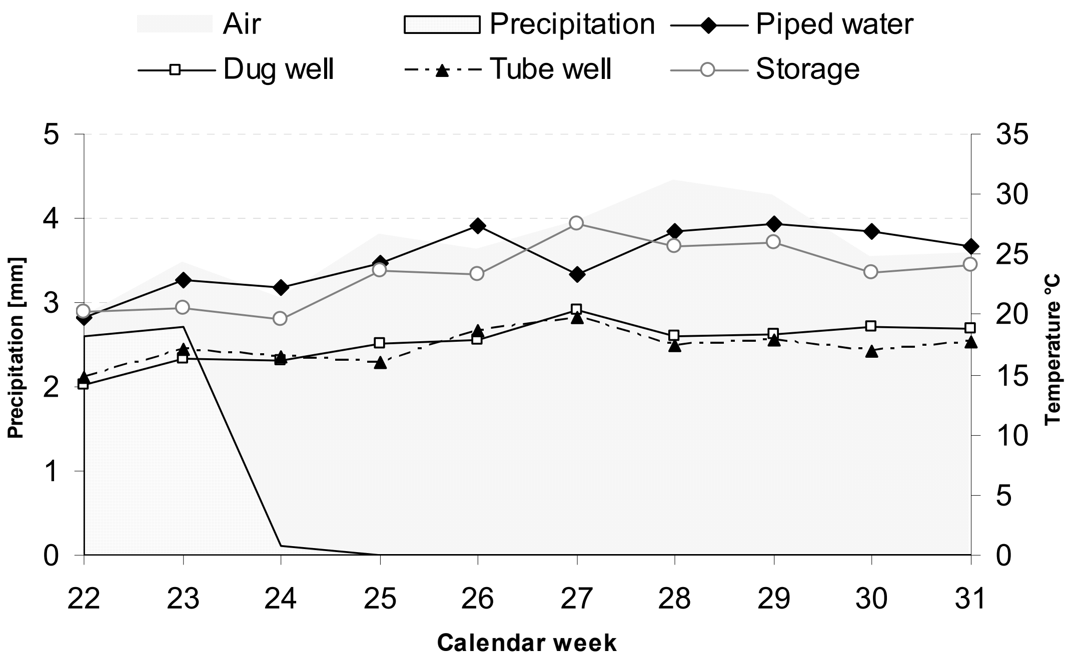

Figure 3.17 Weekly mean precipitation and temperature of water sources and air

Turbidity

Of the drinking water samples, 15% were turbid. The degree of turbidity was in 8% weak, in 5% medium and in 2% strong. The highest turbidity was detected in the piped water, where 36% of the samples showed different turbidity. Weak turbidity was found in 17%, medium turbidity in 14% and strong turbidity in 5% of the samples. Samples from tube wells were much less turbid: for 3% weak and for 2% medium turbidity was recorded. Weak turbidity for water from dug wells was reported only for one sample (0.01%). In 5% of the samples from the household drinking water storage weak turbidity was detected.

Color

Of the drinking water samples, 96% showed no color. For 2% of the samples a brownish and for the remaining 2% a yellowish color was recorded.

Water temperature

At the time of sampling, piped water on average had the highest temperature with a median temperature of 25°C. The median temperature for other drinking water sources was 17°C for tube wells, 18°C for dug wells and 24°C for the household drinking water storage. At the drinking water storage, the highest variation of temperature was measured, ranging from 17°C to 33°C, depending on the source water temperature and the duration of storage (Figure 3.17).

Nitrate and nitrite

Figure 3.18 shows the nitrate concentration in drinking water from different sources. Nitrate concentration in piped water (median 0, mean 2.14, range 0 - 10 mg/L) did not exceed the critical limit of 50 mg/L (European Union, 1998; WHO, 2004). Drinking water from dug wells contained more nitrate than piped water but was on the average also below the critical limit (median 10, mean 16.9, range 0 - 50 mg/L). The median for nitrate in drinking water samples from tube wells was 25 mg/L (mean 45 , range 0 - 250 mg/L), but 11 outliers extended the box' size more than 3-fold. Drinking water from the household storage never contained more than 25 mg/L nitrate. Separate analysis of dug well and tube well sampling points shows that four dug wells contained less than 10 mg/L nitrate (median). For two dug wells (number 7 and 27) the median concentration varied around the critical limit (Figure 3.19). The nitrate concentration in drinking water from tube wells varied substantially between different sampling points

(Figure 3.20). Three out of 10 tube wells permanently contained excess nitrate above the critical limit, which might pose a risk to infant health.

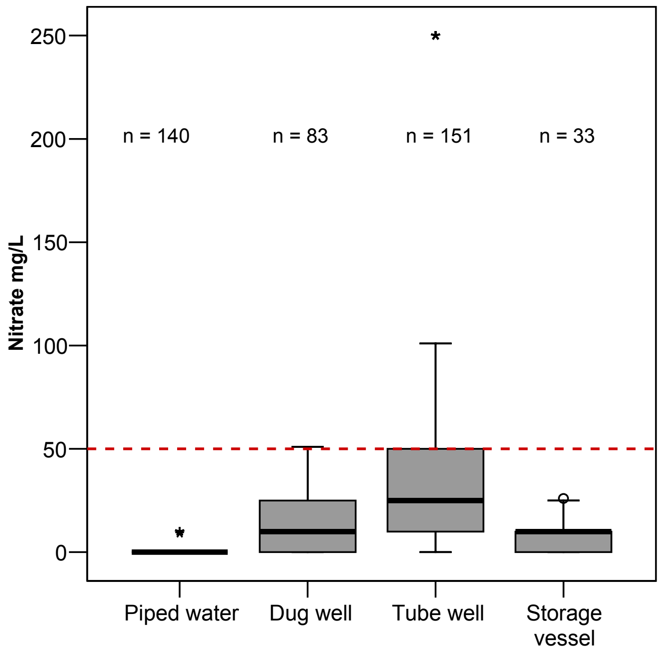

Figure 3.18: Nitrate levels of different drinking water sources and stored water

Nitrite (1 - 2 mg/L) was proven exclusively in drinking water samples from tube wells. In the water from the sampling point number 35, the presence of nitrite was proven nine times. Nitrite was detected once or twice in sampling points number 3, 19 and 31. According to the WHO GDWQ, the provisional guideline nitrite value for short-term exposure is 3 mg/L and for long-term exposure 0.2 mg/L. Because of the possible simultaneous occurrence of nitrate and nitrite, the sum of the concentration ratios should not exceed 1.

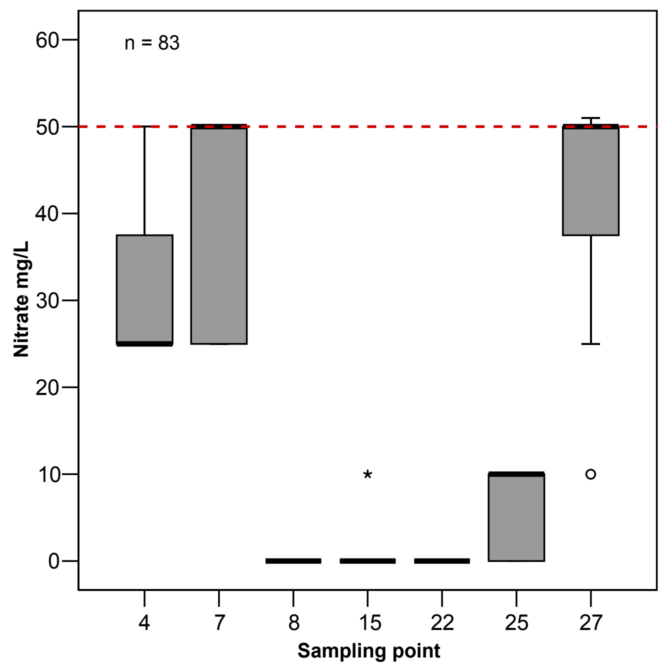

Figure 3.19 Nitrate levels of drinking water from dug wells

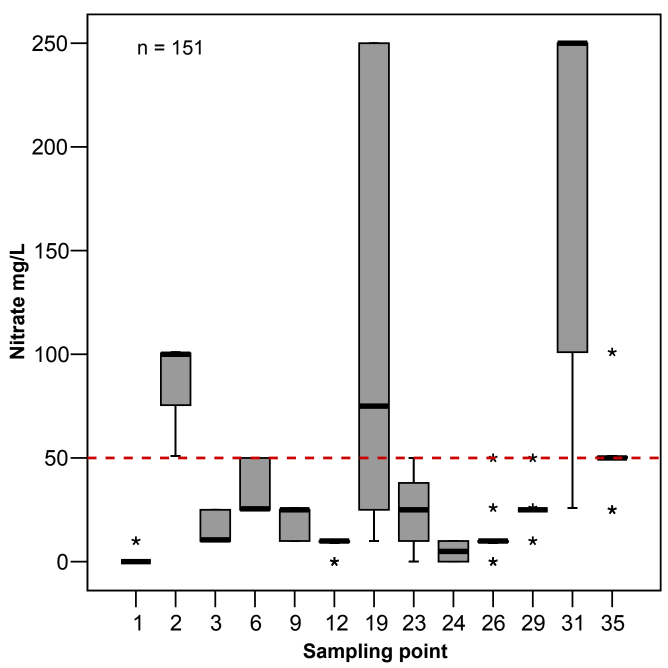

Figure 3.20 Nitrate levels of drinking water from tube wells

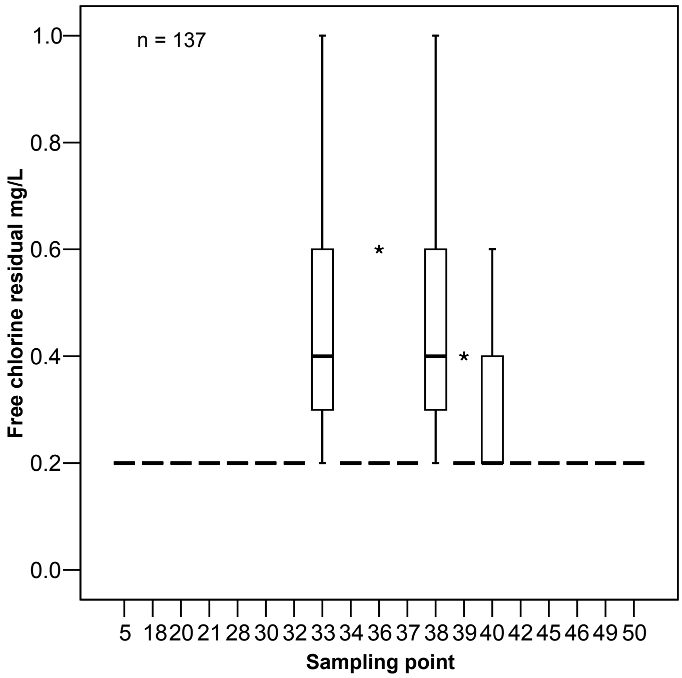

Figure 3.21 Free chlorine residual levels in piped water samples

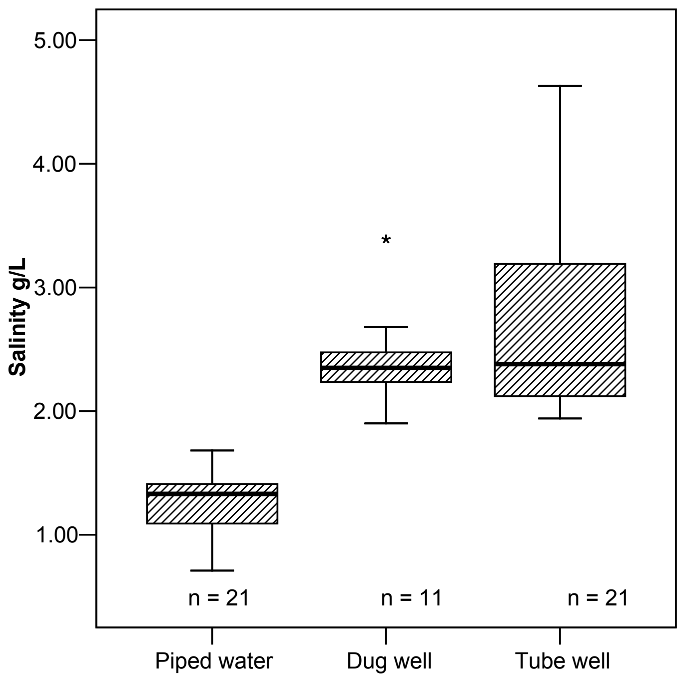

Figure 3.22 Salinity of the different drinking water sources

Free chlorine residuals

The minimum detection level using the Lovibond® colorimetric comparator is 0.2 mg/L. In 84% of the drinking water samples, the level of free chlorine residuals was ≤ 0.2 mg/L. Free chlorine residual levels between 0.4 and 1 mg/L were proven in 22 samples (16%) from 5 sampling points. Frequently higher levels of free chlorine residuals were reported for the sampling points number 33, 38 and 40 (Figure 3.21). All 3 sampling points were situated in urban *mahallas* (Korovul, Gulchilar, Dustlik) of Urgench city.

pH

The pH was measured once in 8 piped tap, 4 dug well and 8 tube well drinking water sampling points. The overall pH median was 7.2. According to the drinking water sources, the following median pH values were found: piped water 7.9 (range 7.7 - 8.1), dug well 7.1 (range 6.8 - 7.4) and tube well 6.9 (range 6.6 - 7.3). As pH has no direct impact on consumer health, a health-based value was not defined, but it is one of the most important operational water quality parameters. The optimum pH for drinking water ranges between 6.5 and 8. For effective disinfection with chlorine, the pH should be less than 8; lower-pH water is likely to be corrosive.

Salinity

The salinity was measured twice for all drinking water sampling points except the storage vessels. All drinking water sources located in the studied *tumani* Urgench, Khiva and Kushkupyr contained increased levels of salt. Piped water contained on average 1.3 g/L salt (median) ranging from 0.7 to 1.7 g/L. For dug wells the salt level ranged from 1.9 to 3.4 g/L with the median of 2.4 g/L. The median salt concentration of tube well water was the same as for the water in dug wells, but the variance between the different tube well sampling points was much broader (range 1.9 - 4.6 g/L). The highest level of salinity was reported for two tube wells in the urban *mahalla* Kumyaska located in Khiva *tuman*.

According to the amount of total dissolved solids (TDS), also named salinity, water is classified into non saline (<500 mg/L), slightly saline water (>500 - 1,500 mg/L), moderately saline (>1,500 - 7,000 mg/L), highly saline (>7,000 -

15,000 mg/L), very highly saline (>15,000 - 35,000 mg/L) and seawater (>35,000 mg/L) (Rhoades et al., 1992). For human consumption, salinity levels above 1,500 mg/L are not acceptable.

Electric conductivity

Electric conductivity measurements were conducted once for drinking water sampling points from 8 piped taps, 4 dug wells and 8 tube wells. On the whole, the median for the electric conductivity was 2333 µS/cm. An electric conductivity of 2500 µS/cm corresponds to the presence of approximately 2 g/L salt. The lowest median electric conductivity of 1355 µS/cm (range 637 - 3900 µS/cm) was proven for piped water samples. Drinking water from dug wells had a median electric conductivity of 2505 (range 2227 - 2690 µS/cm). Electric conductivity of tube well water ranged between 1350 and 4300 µS/cm with a median of 2570 µS/cm. The measurements of electric conductivity correspond well with the results for salinity.

Oxygen

The oxygen level was determined once for drinking water sampling points from 8 piped taps, 4 dug wells and 8 tube wells. The median oxygen level for all samples from different sources was 5.0 mg/L. The median oxygen level for piped water samples was 5.5 mg/L (range 3 - 6.6 mg/L) and for drinking water from dug wells 4.4 mg/L (range 3.6 - 5.1 mg/L). Tube well samples had a medium oxygen level of 4.8 mg/L (range 3.1 - 6.9 mg/L). Roughly, the oxygen content of surface water should not fall below a value of 5 mg/L. Pure deep groundwater is free of oxygen. Oxygen in the drinking water has no direct impact on human health. For prevention of corrosion in the drinking water distribution network, an oxygen level of 5 - 6 mg/L is assessed as optimal (Hütter, 1994).

3.5 Discussion

3.5.1 Fecal contamination

Drinking water is known to be a vehicle for fecal-oral disease transmission (WHO, 2004). Waterborne diseases occur due to ingestion of drinking water contaminated with bacteria, viruses or protozoa. Among the classical waterborne diseases are diarrheal diseases, like cholera (*Vibrio cholerae*), typhoid fever (*Salmonella typhi*), amoebic dysentery (*Entamoeba hystolitica*) and shigellosis (*Shigella* spp.). Other types of diseases are also known to be waterborne, e.g., hepatitis A and E, poliomyelitis, viral meningitis, ocular disease, methemoglobinemia and pneumonia (Payment, 2003).

Specific monitoring of pathogens, as a part of the surveillance strategy for the prevention of waterborne diseases, would be impractical due to the variety of pathogens and costs. Hence, monitoring for fecal indicator bacteria is recommended and widely practiced. Determination of indicator bacteria is a simple and at the same time very reliable method for the detection of fecal contamination of drinking water. A suitable indicator should be present when the respective pathogen is present and be absent in uncontaminated water. The number of non-pathogenic indicator bacteria should exceed the number of the bacteria it is supposed to indicate. It should respond to treatment processes and environmental conditions similar to the pathogen (Hrudey and Hrudey, 2004). Inability to multiply in water, easy and reliable isolation, identification and enumeration are further properties of an optimal indicator bacterium. There is, of course, no single and ideal indicator bacterium for all waterborne pathogens.

So far, the most appropriate fecal indicators are *E. coli* and the thermotolerant coliforms (Horan, 2003) which represent a subset of the total coliform bacteria group. They are excreted with the feces of humans and mammals and their presence in drinking water proves fecal contamination. Both, *E. coli* and thermotolerant coliform bacteria, must not be present in a 100 mL sample of water directly intended for drinking in distribution systems and decentralized supply (WHO, 2004).

Total coliform bacteria include a wide range of aerobic and anaerobic bacteria, which live in the gut of humans and other mammals as well as in the environment. Some of them are able to survive and multiply in water. Hence, they are of limited use as indicators for fecal contamination, but common as indicators for treatment and distribution system integrity (Ashbolt et al., 2001; WHO, 2004). According to the EU

Drinking Water Directive (98/83/EC), coliform bacteria must not be present in a 100 mL sample.

Organisms of the fecal streptococci group are another fecal indicator, which comprises species of the genera *Enterococcus* and *Streptococcus*. They are predominantly of fecal origin. The subgroup intestinal enterococcus is more specific for fecal pollution than the streptococci group. All survive in the environment longer than fecal coliforms and persist mainly without multiplication (WHO, 2004). Although they fulfil most of the requirements for a perfect fecal indicator, still existing difficulties in differentiating fecal from non-fecal enterococci restrict their use as indicator bacteria (Ashbolt et al., 2001; Horan, 2003). Enterococci must not be present in a 250 mL sample (European Union, 1998).

The studied drinking water sources (piped water from taps, dug wells, tube wells, drinking water stored in the household) were contaminated to a different extent with bacteria of fecal origin. As expected, bacteria concentrations increased constantly for all sources corresponding to rising air temperatures over the monitoring period. Overall, piped water and tube well water had a similar microbiological quality, but contamination with fecal coliforms was 3-fold higher for water from piped taps situated in the yard or on the street than for taps located inside the house and tube wells (see 3.3.2). All outside piped taps were surrounded by uncovered soil, which could have caused the contamination at POU.

Dug wells are prone to various forms of pollution. Possible contamination sources are nearby latrines, surface water seeping into the well, use of dirty vessels for drawing the water, and garbage or other objects falling into the well (Hunter, 1997). The sampled dug wells were mostly located further from vegetable gardens and latrines than the tube wells but were often not protected (i.e., no apron or cover). On average, dug wells are older and shallower than tube wells, which makes them more vulnerable to pollution. For example, on the inner brick wall of one dug well (sampling point number 22) mushrooms grew abundantly (Figure 3.8). In a cycle of 3 to 4 weeks the mushrooms grew, died off and fell into the drinking water source causing substantial microbiological contamination. The vulnerability of dug wells to pollution is reflected by the presence of fecal indicator bacteria in at least 50% of the weekly samples.

Assuming that conditions of drinking water supply similar to those found in this study are typical for the Khorezm region, an estimated 85,000 households (24% of population = 340,000 persons) are being exposed to fecally contaminated drinking water. This rough, but conservative estimation of the magnitude of contamination assesses that of those households, 8% are consumers of piped water with taps inside the house, 4% collect piped water from taps outside the house, 6% draw their water from dug wells and 6% from tube wells.

Another hygienic POU problem is the common practice of pouring water into hand pumps for priming. For the sampled tube wells operated by hand pumps, where this practice was used, the rate of fecally contaminated samples increased substantially (see Table 3.3). During sampling, water was only poured into the hand pumps where necessary. In daily life it can be observed that respondents apply this method in order to speed up water abstraction. Once a tube well has been contaminated by improper hand pump handling, water of originally good microbiological quality is thus lost a as safe drinking water supply.

Many studies have observed water quality deterioration caused by household drinking water storage (Brick et al., 2004; Hoque et al., 1999; Lindskog and Lindskog, 1988; Pinfold, 2003; Trevett et al., 2004). Results from this study also prove that deterioration of drinking water quality is frequent.

Water from the piped drinking water supply inside the house and tube well water has a substantially better microbiological quality than water from dug wells. Deterioration of drinking water quality over the period of storage occurs for all sources. Similar results concerning source quality and deterioration of dug well and tube well water have been described recently by Trevett et al. (2004).

3.5.2 Heterotrophic Plate Count

At the end of the 19th century, Robert Koch was the first to use HPC tests to prove the effectiveness of sand filtration of drinking water. After a period where indicators proving fecal contamination were favored and HPC was neglected in many countries, HPC measurement as an indirect indicator of drinking water safety has gained new importance (Expert Meeting Group Report, 2003). HPC detects a wide spectrum of heterotrophic microorganisms from natural microbial flora and pollution sources.

Different cultivation techniques at different temperatures detect only a small proportion of the microorganisms contained in the water, including coliform bacteria and spore formers. In general, increased presence of heterotrophic microorganisms indicates unfavorable drinking water conditions. In piped distribution systems, HPC monitoring is used as a tool for the indication of operational problems caused by recontamination, re-growth, biofilms, absence of residual disinfectants, stagnation or presence of nutrients (LeChevallier, 2003; WHO, 2004). Their presence in well water can indicate surface water inflow and microbial groundwater contamination. According to the German Drinking Water Regulation, the critical limit in drinking water is 100 CFU/mL.

HPC microorganisms as such represent a contamination of drinking water, but cannot be quantitatively related to the risk of illness in general (Hunter, 2003; Rusin et al., 1997). On the contrary, the increasing number of immunocompromised people, e.g., AIDS and cancer patients, are at an increased risk of falling ill by ingesting opportunistic microorganisms (Glasmacher et al., 2003).

Weekly drinking water samples from all sources in the Khorezm region to a varying degree exceeded the HPC limit in May and June. Then, in the course of July, HPC (> 100/mL) constantly increased for the samples taken from the POU (taps) in the water supply system, which coincided with the high counts for fecal indicators in the same period (see 3.3.2). Reasons for this increasing microbial contamination of the drinking water supply infrastructure are unclear, but operation and maintenance problems in the distribution network are known to exist. According to Tokajian and Hashwa (2003) intermittent water supply – common in the study area, due to raw water shortages at that time of the year– causes changes in HPC. Flow interruption and flow restart can cause release of microbes by biofilm tear-off, which results in increased bacteria levels. Leakages and low pressure in the pipe network lead to the contamination by infiltration of sewage or surface water (Egorov et al., 2002). Because of the increasing, but still hidden, morbidity of AIDS/HIV resulting in an increasing immunocompromised population share in Central Asia (1 million), this issue might gain importance for public health considerations in the long run.

3.5.3 Physico-chemical parameters

Regarding nitrate concentration of drinking water samples, it is striking that nitrate levels were only exceeded in the samples from tube wells. Through leaching or surface run off from agricultural land, nitrate from nitrogen fertilizers can be transferred into groundwater and surface water, which will later be used for drinking water purposes. During the Soviet period and as long as the stock piles were sufficient, enormous amounts of mineral fertilizers were applied to agricultural land in Uzbekistan.

Tube wells are often situated at the edge of the vegetable garden, which makes them prone to contamination via agriculture, whereas dug wells are usually located on the street. Tube well sampling point number 19 was situated in the yard together with a sheepfold. During the first four weeks excess nitrate was 250 mg/L, which steadily fell to 10 mg/L in July. The owner confirmed that a substantial amount of manure had been applied in spring. Sampling points number 2 and 31, were also located in the vegetable gardens where mineral fertilizer or manure had been applied in spring. In sampling point number 31 the excess of nitrate decreased from 250 to 100 mg/L in July, with the exception of one outlier (25 mg/L) at the beginning of June.

The presence of nitrate can also be an indirect indicator for fecal pollution due to on-site sanitation (Cave and Kolsky, 1999; Grohmann et al., 2002; Lawrence et al., 2001). In the majority of Uzbek households, on-site sanitation is a common practice and pit latrines are mostly located on the periphery of the vegetable gardens. In contrast to the outcomes of the 'Needs Assessment for the Proposed Uzbekistan Water Supply, Sanitation and Health Project' (Kudat et al., 1995), the present study found both safety distance violations between latrine and drinking water sources and at the same time increased levels of nitrate in the household's drinking water source, which might pose a health risk to consumers of this water. This is valid for the tube well sampling points number 2 and number 19, where the distance was less than 15 m and the median nitrate levels above the critical limit (Figure 3.20). The sampling point number 31 – where nitrate levels were the highest – keeps a distance of 18 m to the pit latrine. The optimal distance between latrine and drinking water source is dependent on the velocity of the groundwater flow and the soil texture, varying for each site. As a rule of thumb, the distance should not be less than 15 m.

The critical level for nitrate is 50 mg/L (European Union, 1998; WHO, 2004). The primary health concern regarding excess nitrate and nitrite in drinking water is methemoglobinemia, also known as ‘blue baby syndrome’. Physiologically, the stomach of infants has a low gastric acidity. Nitrate in this milieu is reduced to nitrite by gastric bacteria. Nitrate oxidizes fetal bivalent hemoglobin to trivalent methemoglobin, which is unable to transport oxygen in the human body. The reduced oxygen level in the infant’s blood causes exertional dyspnoea, cyanosis and respiratory depression. In serious cases, stupor and asphyxia will develop and lead to the death of the individual (Hunter, 1997).

Gastro-intestinal infections exacerbate conversion from nitrate to nitrite, especially in children (Höring, 2003; Knobeloch et al., 2000). Methemoglobinemia affects hundreds of infants in the United States each year (Knobeloch et al., 2000) and is regarded as a common public health problem in the Eastern Europe (Ayebo, 1997). Case studies prove this serious medical condition in infants under 6-months that are bottle-fed with formulas prepared with nitrate-contaminated water from wells. In some case studies, the water used for preparation of formulas contained even less than 50 mg/L of nitrate (Knobeloch et al., 1993; Knobeloch and Proctor, 2001; Knobeloch et al., 2000). Other authors state that nitrate is a co-factor in one of several causes of the disease (Fewtrell, 2004). Given the paucity of results, this issue needs further research. Studies that examine associations between the different causing factors may be of particular interest.

Nitrate also aggravates iodine deficiency, leading to gland hypertrophy and resulting in iodine deficiency syndromes such as goitre and mental retardation. Nitrate ions inhibit transport of iodine ions to the gland cells. Under balanced nutrition, the human body is able to compensate for iodine deficiency. In iodine-depleted regions, the human body is not able to compensate iodine under-supply, and deficiency syndromes occur (Grohmann et al., 2002). Health specialists in Uzbekistan state that gland diseases, in particular goitre and endocrine disruptions, are increasing health problems. The results of the focus group discussions also show that the population regards gland diseases as a relevant health problem (Table 4.7).

In this study, 25% of all wells at least occasionally had nitrate concentrations higher than 50 mg/L (60% > 25 mg/L). On average, about 50% of the population utilizes shallow groundwater for drinking water purposes. If the rate of contamination is similar in the other districts of Khorezm, an estimated number of 44,500 household water supplies may fail to meet the standard. Based on current yearly birth data, 6,290 infants (under 6-months of age) are expected to live in homes that have, at least from time to time, nitrate-contaminated water supplies. Assuming a threshold concentration of 25 mg/L, about 15,100 children are exposed.

Another human-induced water quality problem in the Khorezm region is the high salinity in all drinking water sources (see 3.4.2). In arid regions, where irrigation without proper drainage is practiced, the salt content of soils and subsequently of groundwater increases. In the study area, over decades those practices have led to high soil and groundwater salinity (Ibrakhimov, 2004).

The salinity of drinking water samples from dug wells and tube wells varied substantially; the taste threshold of about 200 mg/L (WHO, 2004) was exceeded roughly around 10-fold in all well water samples. The determined median salinity of 2.4 g/L of well water exceeded results from the 'Hand Pump Monitoring Survey' (Kudat et al., 1996b), which detected an average of 1.7 g/L for Khorezm. According to the 'Salinity Taste Tolerance Assessment' (Kudat et al., 1996a), levels up to 2 g/L are acceptable for local residents. The Uzbek State Standard (Republic of Uzbekistan, 2000) sets limits at 1 g/L for piped water and 1.5 g/L for decentralized sources such as wells.

The role of dietary sodium and potassium intake as a risk factor in the development of hypertension has been extensively reported. The INTERSALT study found an independent association between 24 h urinary sodium excretion and systolic blood pressure (Intersalt Cooperative Research Group, 1988). The American Heart Association (2005) recommends a total daily sodium intake of 2.4 g. Assuming a medium to low drinking water intake of 3 L per day under the prevailing arid conditions, a larger part of the population of Khorezm, where the water supply is based on groundwater abstraction, may take in more than 10 g/day of sodium via drinking water. Water, as a source of sodium, has only rarely been addressed in studies on the relationship between hypertension and salt intake (Pomeranz et al., 2000; Robert and Edward, 1981; Tuthill and Calabrese, 1979). The long-term impact on human health due to continuous consumption of saline drinking water has not been studied. However, regular consumption of saline drinking water has at least an effect on the regulating functions of the human body (Grohmann et al., 2002).

The pH of drinking water has no direct impact on the consumer, but it is an important operational water quality parameter (WHO, 2004). It influences chemical reactions within the distribution system depending on the material of the water pipes. As aluminium and heavy metal levels in water with low pH might increase depending on the pipe material, the use of pipe materials should take into account the pH values of the drinking water. There is no health-based guideline. The WHO GDWQ published in 1984 recommended a pH value range of 6.5 - 8.5, which might be broader in absence of distribution systems. In the latest issue of the WHO GDWQ (2004), it is simply stated that the optimum pH value is often referred to be in the range of 6.5 - 9.5. Values between 7.8 and 8.5 do not foster corrosion and subsequently take up of metal ions in piped drinking water. For drinking water with a pH below 7.4, copper piping and for drinking water with a pH below 7.8, zinc piping is not recommended (Grohmann et al., 2002). Thus, the pH values of the piped water measured in the Khorezm region show no restrictions for pipe materials.

Turbidity is a measure of the cloudiness of water and is caused by suspended particles that are capable of scattering light. Microorganisms are usually attached to the particles, which can protect microorganisms from the effect of disinfection (WHO, 1997). Turbidity has been used as a proxy for exposure in many epidemiological studies. An association between increased turbidity levels and gastro-intestinal diseases has been detected extensively (Egorov et al., 2003; MacKenzie et al., 1994; Morris et al., 1996; Schwartz et al., 2000).

Disinfection of drinking water prevents microbial contamination and re-growth in the distribution system (Hunter, 1997; Morató et al., 2003) by inhibition of heterotrophic microorganism growth and deactivation of small amounts of pathogens entering the distribution system. Disinfection of drinking water can be achieved by chlorination, solar radiation, ozonation and UV-disinfection. Chlorination is the most frequent method for disinfection of drinking water. Chlorine can be added as liquid, solid or gaseous compounds. The chlorine compound reacts with the water forming acids and ions, which then act as disinfectants and destroy most of pathogenic microorganisms (Grohmann, 2002). The applied chlorine usually allows formation of free chlorine residuals after contact time. In well maintained distribution systems, disinfection can prevent microbiological re-growth but in distribution systems with operational problems, coliform bacteria have been proven even when free chlorine residuals averaged between 2 and 2.5 mg/L (LeChevallier, 2003).

For insufficiently treated drinking water or badly maintained distribution systems with cracks and leakages through which sewage or surface water may enter, even high free chlorine residual concentrations cannot ensure safe drinking water. Because of their strong chlorinous taste, high levels of disinfectant residuals cannot be continuously maintained. The taste threshold for free residual chlorine concentration (0.6 - 1.0 mg/L) is far below the guideline value of 5 mg/L (WHO, 2004).

In the present study, the drinking water sampling documented substantially varying chlorine levels and turbidity (36% of samples) in the distribution system. At only 3 POU sampling points in the network in Urgench city were free chlorine residuals up to 1 mg/L found. For the majority of piped tap sampling points, very low levels of free chorine residuals – as also found by Egorov et al. (2002) for a Russian city – were detected.

For assessment of problems in the distribution system, it would have been necessary to have a look at the respective maps, which was, unfortunately, impossible by reason of confidentiality. So, no problem regions in the distribution network could be identified. But it is likely that those sampling points with high free chlorine residuals were located closer to the service reservoir than those with low levels. Because of the frequent turbidity of the treated drinking water, bactericidal levels might decrease over the travel distance, resulting in very low levels at the POU.

4 EPIDEMIOLOGICAL MONITORING

4.1 Introduction to epidemiological monitoring

Despite constantly decreasing numbers, diarrhea has an enormous share in the global burden of disease, especially in children (Guerrant et al., 2002b). Children are the most vulnerable group and diarrhea is a major cause of childhood mortality worldwide (Black et al., 2003). Every year, more than 2 million children, predominantly in non-industrialized countries, die due to diarrhea (Kosek et al., 2003) caused by bacteria, viruses and protozoa and mostly transmitted via the fecal-oral transmission route.

Among the risk factors for fecal-oral transmission route are: low socio-economic status, poor hygiene, malnutrition, non-breast-feeding infants, parenthood, work with animals, time spent in an institutional setting, e.g., kindergarten (Byers et al., 2001). Quantitative measurements of exposure to risks, arising from the different fecal-oral transmission routes, are too comprehensive to be covered in a single study. Therefore, in epidemiology, surveys are often used to assess environmental exposure. Here, the combination of quantitative and qualitative methods enhances and complements the findings of the survey (Lampietti, 2000; Nichter, 1991).

Since the independence of Uzbekistan in 1991, the registered cases of diarrheal diseases – obtained by passive surveillance – are constantly decreasing. Since the prevailing socio-economic situation has worsened and the governmental health expenditures have halved during this period, a change in the health care seeking behavior or a lack of reporting are likely to have caused this decrease.

Snyder and Merson (1982) have proven that outcomes of active diarrheal disease surveillance considerably exceed the data derived from passive surveillance. The more frequently was surveillance carried out, the higher was the incidence of diarrheal diseases. In the present study, active surveillance data on diarrheal diseases and data on environmental risk exposure, obtained by use of different qualitative methods, served as basis for the risk factor analysis. Multivariate analysis focuses on associations between exposure to risk factors and disease outcome on the inter-household-level. Descriptive statistical analysis of survey data gives insight into household drinking water issues, hygiene, health-related behavior and child care.

4.2 Fecal-oral disease transmission

The group of fecal-oral transmitted diseases includes viral hepatitis A, viral hepatitis E, cholera, typhoid fever, giardiasis, cryptosporidiosis, other diarrheal diseases and other diseases. Infections caused by ingested viruses, bacteria and protozoa contained in fecal matter predominantly manifest in diarrhea (Byers et al., 2001). According to the mode of transmission, fecal-oral diseases can be classified into: foodborne, waterborne, person-to-person and via the environment. Most pathogens can be transmitted by more than one route, some of them multiply in the environment, others do not (Table 4.1).

Disease transmission is also influenced by the biological factors of the host and the pathogen. The host's risk of infection depends on exposure to pathogens and the organism's resistance to infectious agents. Subsequently, children and elderly people with a weaker immune system as well as immunocompromised persons, e.g., after chemotherapy, being HIV positive or suffering from carcinomas, are at increased risk of gastro-intestinal infections. Other influencing host characteristics are nutritional status, health status, age, sex, personal hygiene and food hygiene (Carr, 2001). Pathogen-related biological factors are: ability to survive and multiply in the environment, incubation period, the infective dose, and the mode of fecal-oral transmission.

Water quality and quantity also influence fecal-oral disease transmission. On the one hand, the disease can be transmitted to the victim via fecally contaminated water. In situations where diarrheal disease is not endemic, this can lead to large epidemics. On the other hand, water-washed disease transmission can occur when not enough water is available for washing and personal hygiene; this also contributes to endemic diarrheal disease.

Table 4.1 Selected fecal-oral pathogens and transmission routes (Byers et al., 2001; Carr, 2001)

Pathogen		**Reservoir**	**Transmission mode**			Multiplies in food
Genera	Family		Waterborne	Foodborne	Person-to-person	
Virus	Hepatitis A	Humans	+	+	+	–
	Hepatitis E	Humans	+	+	+	–
	Norovirus	Animals, humans	+	+	+	–
	Rotavirus	Animals, humans	+	+	+	–
Bacterium	*Campylobacter jejuni*	Animals, humans	+	+	+	+
	Enterotoxigenic *E. coli*	Humans	+	+	+	+
	Enteropathogenic *E. coli*	Animals, humans	+	+	+	+
	Enteroinvasive *E. coli*	Humans	+	+	?	+
	Enterohaemorrhagic *E. coli*	Animals, humans	+	+	+	+
	Entamoeba histolytica	Animals, humans	+	+	+	–
	Salmonalla typhi	Humans	+	+	±	+
	Salmonalla non-typhi	Animals, humans	±	+	±	+
	Shigella spp.	Animals, humans	+	+	+	+
	Vibrio cholerae O1	Humans, sea water	+	+	±	+
	Vibrio cholerae non O2	Animals, humans	+	+	±	?
	Yersinia enterocolitica	Animals	–	+	–	?
Protozoa	*Cryptosporidium parvum*	Animals, humans	+	+	+	–
	Giardia lamblia	Animals, humans, environment	+	±	+	–

+ yes, - no, ? no information

Another classification of disease transmission refers to the domestic domain and the public domain. This concept cuts across the preceding transmission modes and should be regarded as complementary. The domestic domain is under the control of a household and disease transmission depends on peoples' behavior. Transmission in the public domain (work places, public institutions, recreational places) is potentially more threatening to public health. Interruption of transmission routes in the domestic domain can be achieved by health education resuling behavioral changes, whereas in the public domain improvements aim at infrastructure such as piped water supply, sewerage, excreta and solid waste management (Cairncross et al., 1996).

The 'F-diagram' (Figure 4.1) allows a distinction between primary and secondary measures for the interruption of fecal-oral disease transmission. Primary barriers prevent fecal contamination of the environment by means of safe excreta disposal and removal of fecal matter from hands after contact with stools. Secondary barriers are practices that impede fecal organisms – which have already reached the environment – from multiplication and transmission to new hosts. Hence, washing hands before preparing food, eating, feeding infants as well as safe food storing practices and re-heating of left-overs are appropriate measures (Curtis et al., 2000).

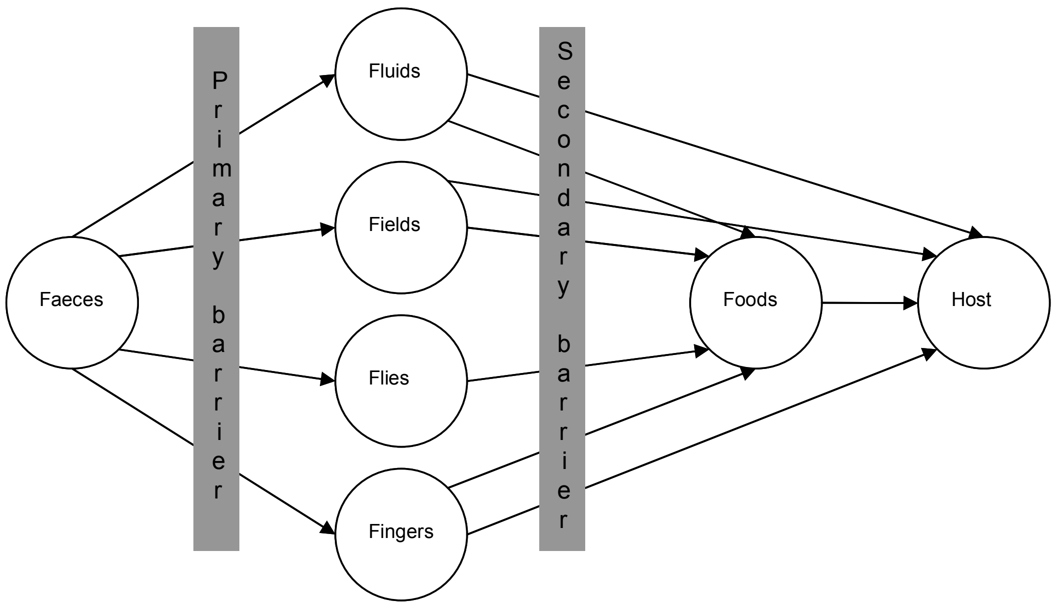

Figure 4.1 The F-diagram modified after Wagner and Lanoix (1958)

4.3 Methodological considerations on epidemiological monitoring

The cohort study – also called incidence, longitudinal, follow-up or prospective study – is designed to compare incidence rates in groups that differ in exposure levels (Beaglehole et al., 2000; Giesecke, 2002; Halloran, 2001). As one aim of the study was to analyze risks for diarrheal diseases from environmental exposure, a cohort of 189 households was followed over a 3-month period in summer 2003. In February 2004, 176 households were monitored for 4 weeks. The risk factor of fecally contaminated drinking water was measured by quantitative methods (see 3.3.1). Other risk factors were assessed using qualitative data obtained by household and community interviews, spot checks and socio-hygienic mapping. To increase the internal validity of the findings, triangulation was performed regarding selected risk factors related to the drinking water issues as well as to domestic and personal hygiene. Triangulation is the application of different data collecting methods to the same research question in order to assess the authenticity of the finding (Chung, 2000).

Infection measurement can be carried out using laboratory and clinical criteria or recall by study participants (Byers et al., 2001). Obtaining laboratory data on the etiology of the infection requires sophisticated laboratory support and is therefore very expensive. More commonly, the disease outcome is measured according to a non-pathogen-specific symptomatic definition of the diarrheal disease episode, which has the disadvantage that it does not detect silent infections. Recall by study participants during regular visits (usually weekly or biweekly) is used to measure incidents of diarrheal disease. As this method is subject to memory lapses and the vast majority (99.3%) of the Uzbek population is literate (UNDP, 2004), the diarrhea incidents were self-reported daily on the basis of a diarrhea diary.

The occurrence of disease can be evaluated using different incidence measures, including proportions and rates (Halloran, 2001; Last, 1995; Nelson, 2001; Pearce, 2003). If the outcome of interest is the overall burden of disease – including repeat diarrhea episodes – the use of a rate can be justified (Byers et al., 2001). So, for this study, the incidence is defined as number of diarrhea episodes divided by the respective sample population (e.g., population per *mahalla*, population exposed to different drinking water sources) during a specified time period. Common disease incidence is usually expressed per unit population per year, e.g., incidence/1,000 x year

(Giesecke, 2002). In this study, the incidence is expressed per 100,000 population per year, month or week, because this measure facilitates comparison with official registration data. Person-time incidence (episodes/person x year) is used for analysis of age strata and overall estimates.

Official registration data (passive surveillance) show strong seasonal variation of all acute infections (diarrheal disease), always peaking in July over the last decade. A study conducted by (Semenza et al., 1998) confirmed this disease pattern also for Karakalpakstan. As exposure to pathogens can vary with the season, seasonality with a summer peak of diarrheal disease was assumed as likely, a study period from May till the beginning of August was decided on. It was intended not only to document the increase of diarrheal disease from early summer onwards, but also to detect a change in exposure due to the contamination of drinking water.

4.4 Methods

4.4.1 Population and sampling design

It is in the general interest of the pilot project on 'Economic and ecological reconstruction of land and water use in Khorezm region' to generate data in the way that outcomes complement each other. For that reason, the same samples or sampling areas (transects) are used by different project modules. As this was also of common interest for the study on health economics and the study on diarrheal disease, both surveyed the same sample.

Therefore, a sampling strategy that covered the needs of both studies had to be decided on. Elementary units of this survey were households in the Khorezm region. Observational unit was the head of the household. The target population size was about 1.4 million and partitioned into spatial, social and demographic subsets. A multistage sampling was carried out by the health-economic survey in February 2003.

First, the administrative units (AU) Urgench city, Urgench *tuman*, Khiva *tuman* and Kushkupyr *tuman* were selected out of 10 tumani of the Khorezm *viloyat*, according to health indicators, drinking water sources and socio-economic indicators. The number of sampled households (HH) within each of the four administrative units was proportional to the total number of households in the surveyed area NAU = 200 * (number of HH in AU)/(total number of HH in survey area). To balance random sampling requirements and resources needed, survey clusters within the administrative units were identified (Figure 4.2). These clusters – constituted by the smallest administrative units similar to communities – are named *mahallas*.

In order to survey proportional shares of urban and rural households, the *mahallas* were stratified into urban and rural. As the number of rural *mahallas* is similar for the four administrative units, it was decided to randomly select three rural *mahallas* per administrative unit (Table 4.2), which was based on the decision not to survey more than five to six households per urban *mahalla*. This threshold was set to prevent selection bias. The exception was Kushkupyr city, because it had only recently been divided into *mahallas* and has a low number of inhabitants. For that reason, it was treated as one urban *mahalla*. The number of households per selected *mahalla* was calculated as follows $N_{urban\ Khiva}$ = 54 * (number of HH in urban Khiva)/(total number of HH in Khiva).

Table 4.2 Administrative units and household (HH) numbers

	Number of			
Administrative unit	urban mahallas (in sample)	rural mahallas (in sample)	HH	HH (in sample)
Urgench city	34 (10)	0	30,184	54
Urgench *tuman*	0	11 (3)	24,914	46
Khiva *tuman*	16 (3)	9 (3)	29,019	54
Kushkupyr *tuman*	6 (1)	13 (3)	24,673	46
Σ	56 (14)	33 (9)	108,790	200

HH = household

Selection of *mahallas* was carried out using the Excel® random number function. Lists of the households living in the respective *mahallas* were provided by the Hakimyats (district authority). In a final stage the households were selected by random numbers. The study population was closed during the monitoring periods.

Due to demography, changes in the summer and the winter follow-up led to a slightly different study population for the two monitoring periods. In the period between the summer study and the winter follow-up, 22 babies were born, 6 persons died, 9 brides moved in and 10 out, 1 man joined the army and 6 persons returned to their families for the winter time (Table 4.3).

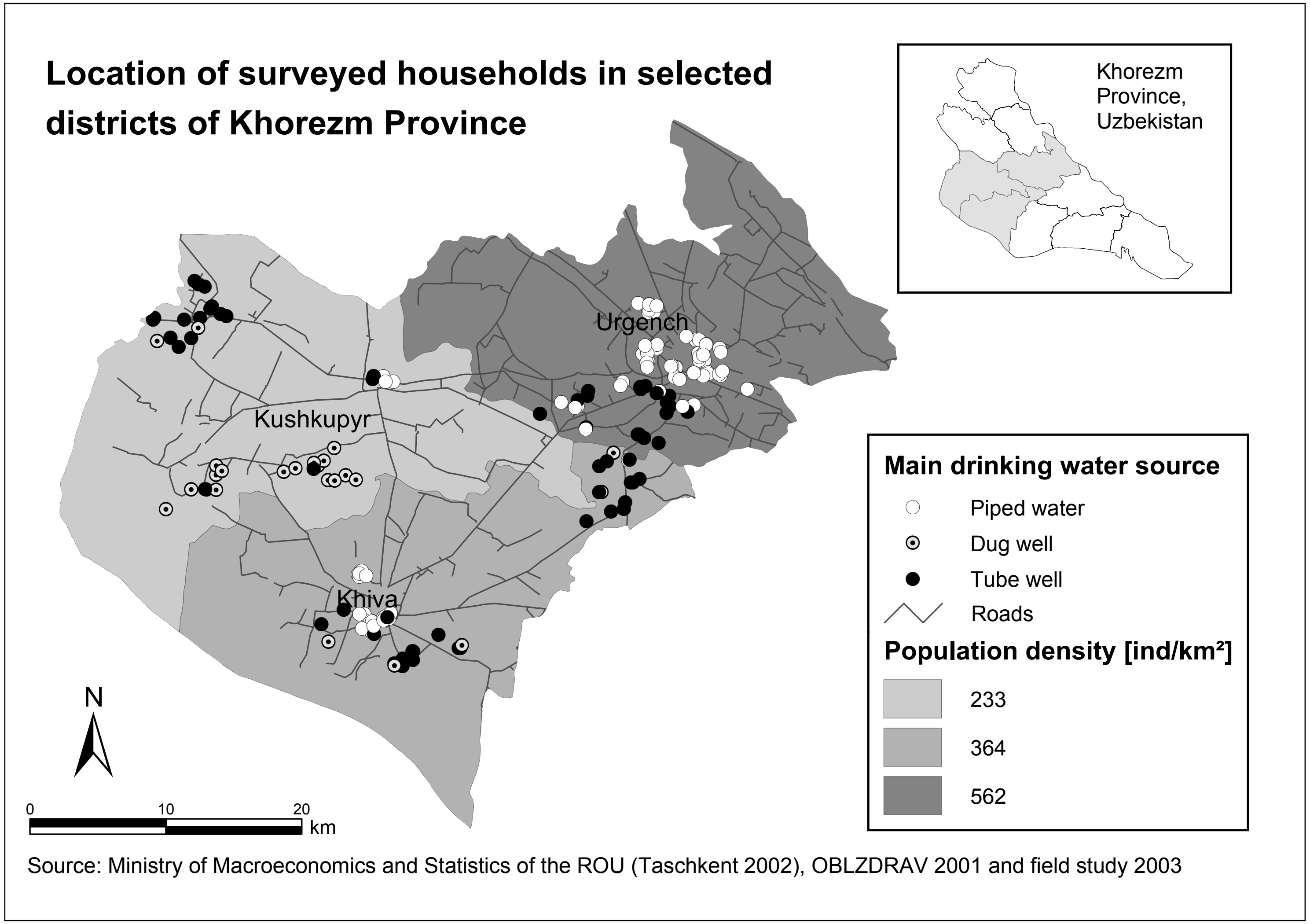

Figure 4.2 Location of surveyed households

Table 4.3 Demographic changes between the summer and the winter follow-ups

No. of individuals in summer survey	Reasons for leaving and joining the sample		No. of individuals in winter survey
	- 6	deaths	
	- 10	brides left sample	
	- 1	went to army	
	- 7	reported regularly in summer but unregularly in winter	
	+ 11	reported regularly in winter but unregularly in summer	
	+ 9	daughters-in-law joined sample	
	+ 22	newborn babies	
	+ 6	temporary family members	
1148			1172

4.4.2 Community interviews

Before the onset of the survey and after the pre-test of different questionnaires, three structured community interviews (Chung, 2000) on the perception of health problems in the region were carried out (Table 4.4). Two interviews were performed with mixed groups, a third with a female group.

First, the heads of the respective *mahallas* – included in the random sample of the household survey – were asked for permission and support of the community interviews. In Uzbekistan, the year 2003 was declared as 'The Year of Healthy Generation', and therefore the *mahalla* heads highly appreciated the activities of the survey. They supported the interviews by informing the community population, especially those included in the sample about the date and called for participation. In the *mahalla* Al Khorazmiy (Urgench), the community interview was videotaped on order of the *mahalla* head.

In Khonobod (Kushkupyr) and Al Khorazmiy, the interviews with mixed groups took place in the community centers. The third interview with the female group took place in the community center of the pilot farm, which is situated in the *mahalla* Okyop (Khiva).

Table 4.4 Community interviews

Group	Mahalla	Date	Duration	Number of adults	Number of voters	Number of HH in sample
1	Al Khorazmiy	24.04.2003	90 min.	50	22	4
2	Khonobod	26.04.2003	60 min.	28	-	11
3	Okyop	12.05.2003	120 min.	14	13	13

HH = household

The three community interviews followed the same structure and topics, but varied slightly in order. First, the facilitators Susanne Herbst and Dr. Fayzieva introduced themselves and the purpose of the ZEF pilot project. After answering questions on the first part, the task of the subproject C2 (the present study) was introduced as a study on health. In order to avoid bias among the participants of the community interviews, the term ‘diarrheal diseases’ was not mentioned by the facilitators. The importance of gaining knowledge of public perception on health and disease was pointed out, followed by a brainstorming on the most urgent health problems in the region. Diseases that came up during the brainstorming served as a basis for the health problem ranking using a flip chart. During all three community interviews, diarrhea was not mentioned by the participants, so the facilitators asked whether diarrhea was included in the term gastro-intestinal diseases or whether it had to be written down as a separate category. After clarification, it had to be written down separately in all three community interviews. Finally, every adult individual was asked to give three votes for the disease or diseases she or he regards as the most important health problem in the region. The flip chart was turned out of the public view and presented to the participants, who put ticks under the disease categories on the flip chart they regarded as the most essential. The community interviews ended with answers to the questions by the interview participants and a comparison of the health ranking outcome with official morbidity data.

4.4.3 Self-reporting of diarrhea (diarrhea diary)

The occurrence of diarrheal diseases was monitored by self-reporting of diarrhea incidents using a diarrhea diary. From 12 May till 3 August 2003 and from 2 till 29 February 2004. The diarrhea diary was a one-page form containing a table where each day of the week was represented as a column and every individual in the household as a line (see Appendix 9.1). The household members were asked to report diarrheal incidences daily using defined symbols.

In order to prevent misunderstandings, the term diarrhea was replaced by the more common Uzbek synonym *ichketar*. Every diarrhea bout was marked in as **X**, nausea as **O** and emesis as **V**. These symbols were also explained beneath the table.

Diarrhea was defined as:

- Three or more incidences of fluid stool within 24 hours,
- Two or more incidences of fluid stool with at last one of the following symptoms: Abdominal pain, cramps, nausea, emesis or fever; or
- the incidence of a single fluid stool with blood or mucus (Baqui et al., 1991; Isenbarger et al., 2001).

A new episode was defined when diarrhea bouts occurred after an interval of at least three symptom-free days (Baqui et al., 1991). Simplified definitions of diarrhea and boxes for metadata in the diary were printed on the back page of the form.

In most households, the household members selected one female person who was to be responsible for keeping the diary. The other household members reported their diarrhea bouts to her. For diarrhea bouts of children, the person in charge was the same as for child care. The pre-test of the diarrhea diary was carried out in the families of the interviewers.

The diarrhea diary was distributed and collected weekly. In order to avoid monitoring gaps, the diary sheet was always handed out one week in advance. In case nothing was entered into the last diary sheet, the interviewer asked whether really no case of diarrhea occurred or they had just forgotten to enter into the diarrhea diary form. In case it had been forgotten, the interviewer entered the respective data according to the statement of the respondent.

For the first distribution of the diary, the interviewers were encouraged to take their time, to explain everything very carefully and to repeat explanations patiently and as often as necessary. Here, it was pointed out that participation in the study would not result in any monetary benefit, but would support the creation of data for action.

Because of the unexpected outcome of the summer monitoring (no peak, tremendously high incidence rates), a follow-up for the period between 2 and 29 February was conducted.

4.4.4 Survey on exposure to risk factors

After having defined the environmental conditions that could pose a risk of diarrheal disease to human health in the Khorezm region, the fundamental sections of the questionnaire were determined (Hartge and Cahill, 1998). The duration of the main interview was fixed to about 30 - 40 minutes. A draft questionnaire was worked out, keeping wording simple and clear (Schnell, 1995). The questionnaire comprised the following sections: children and raising children, health and waterborne diseases, drinking water sources, drinking water treatment, drinking water storage, water consumption, domestic hygiene and food hygiene (see Appendix 9.5). While designing the questionnaire, survey outcomes and questionnaires used by MSF in the 'Knowledge, Attitude and Practice' study (Falzon, 1998) and UNICEF (2001) Multiple Indicator Cluster Survey study were taken into consideration.

Finalizing the first questionnaire draft, different sections of the questionnaire were integrated with each other and with the other forms for qualitative data collection (Grosh and Glewwe, 2000; Schnell, 1995). Metadata information on the interview was placed on the title page and at the end of the interview (Grosh and Munoz, 2000). The interview started with questions on child care, which were not delicate with more sensitive questions concerning personal hygiene posed in-between.

As in the Khorezm region a local dialect is mostly spoken, the wording of the Uzbek version of the questionnaire was revised extensively. The first adaptation of the questionnaire draft to local needs was made during the first interviewer training week. Unclear questions were revised. During this phase every proposed change was translated from Uzbek into English and carefully considered before revision.

Pre-testing (30 questionnaires) was carried out in urban and rural settings that were not included in the sample. After pre-testing, another thorough revision of the questionnaire was made (Grosh and Glewwe, 2000; Schnell, 1995). Finally, to control for precision of translation, a complete translation back from Uzbek into English was carried out by a translator to whom the questionnaire was completely unknown.

The final version of the standardized main questionnaire contained 48 open-ended and 25 closed-ended questions. All answers were pre-coded with numbers, which had to be circled by the interviewer. For the open-ended questions, the last option was always ‘others’, which needed to be specified by a note. The questions were read to the respondent; interviewers were instructed never to read the pre-coded answers.

4.4.5 Spot checks

Domestic hygiene conditions were evaluated by data obtained during spot checks. Indicator spots for assessment of the hygiene status were: drinking water storage, hand wash facility, flush toilet and latrine including disposal of used cleansing material. Spot checks contained both operationalized observations and evaluation of the hygienic conditions by the interviewer. During training of the interviewers, predefined criteria for evaluation were explained in detail. Then, methods for evaluation and operationalization were revised within the team until a common agreement on evaluation criteria was achieved.

Check forms (Appendix 9.2 and Appendix 9.3) created for better feasibility of the spot checks were adapted according to training experience. The spot checks were conducted twice in every household during the 12-week monitoring period in spring and summer 2003 (Table 4.5).

Criteria for evaluation of the drinking water storage vessels took into account the vessel type as critical control point (CCP), as recommended in the HACCP (hazard analysis critical control point) concept for water storage in the house (WHO, 2004). Furthermore, the exact storage place, cleanliness of the containers and visible contamination of the drinking water were checked. The evaluation of the interviewer also included the closer environment of the drinking water storage, e.g., any kind of excreta and waste and the vessel integrity.

The hygienic status of latrines and flush toilets was determined by observing availability of toilet paper or other anal cleansing material, disposal of used cleansing material, presence of flies, odor and visible contamination of the facility with feces.

The first spot check was carried out between the 21st and the 23rd week in spring 2003. On this occasion, the hygienic situation of drinking water storage and latrine or flush toilet was checked (see Appendix 9.2). After asking interviewers had a look at the drinking water storage vessels and the latrine or flush toilet. They marked the memorized hygienic condition in the check form immediately after having left the respective household.

As the second spot check included a short interview, which touched more sensitive topics, it was dated later in the survey period. Up to this time, respondents and interviewers already had a more personal relationship, so it was much easier to ask touchy questions. The second spot check was conducted in the 27th and the 28th calendar week of summer 2003. Basically, it was conducted in the same way as the first; the additional questionnaire used afterwards contained standardized questions on sanitation and defecation habits of children (see Appendix 9.3).

4.4.6 Socio-hygienic scheme

According to the UN definition (United Nations, 1997), a household is defined as a group of two or more persons who live together, pool their money or make common provision for food or other essentials. Administratively, households usually are registered according to their place of residence, which neglects the commonplace rural multi-family household having at least partly a common budget. A sociological study carried out in Uzbekistan (Kandiyoti, 1999) has shown that from these facts, difficulties in the definition of a 'household' may arise. Household numbers according to village administration records might deviate from number of households, if the UN definition is applied or when compared to what the villagers themselves regard as a household. Because the household is often the unit for economic impact assessment, e.g., economic burden from diarrheal diseases, the definition of a household as a sampling unit is of major importance.

In order to overcome such sampling problems, a kind of social mapping on a very small scale (courtyard level) was invented. The major purpose of the mapping was to gain insight into the number of families that constituted a household and into the prevailing hygienic conditions. It also provided some information on socio-economic relations on an intra-household-level. This method is named by the author 'socio-hygienic mapping' and the outcome 'socio-hygienic scheme'. Such a scheme was drawn for every household. Much effort was put into the design of the scheme in order to create very readable and easy understandable information, which can be grasped at a glance (Figure 4.3).

The physical location of the houses around the courtyard is represented as grey rectangles. Capitalized letters indicate the relation between different families. Roman numerals indicate the number of adults living in the family, the number of children is displayed by Arabic numerals. Unambiguous symbols are used to draw number and location of hygiene facilities and socio-economic linkages. The non-capitalized family initial indicates which families use the respective resource or facility. Additionally, the location and depth of a dug or a tube well are noted down. The distance between a well and the next latrine was measured by counting steps, having determined the mean step length of each interviewer before. Finally, it is indicated which facilities were used by neighbors.

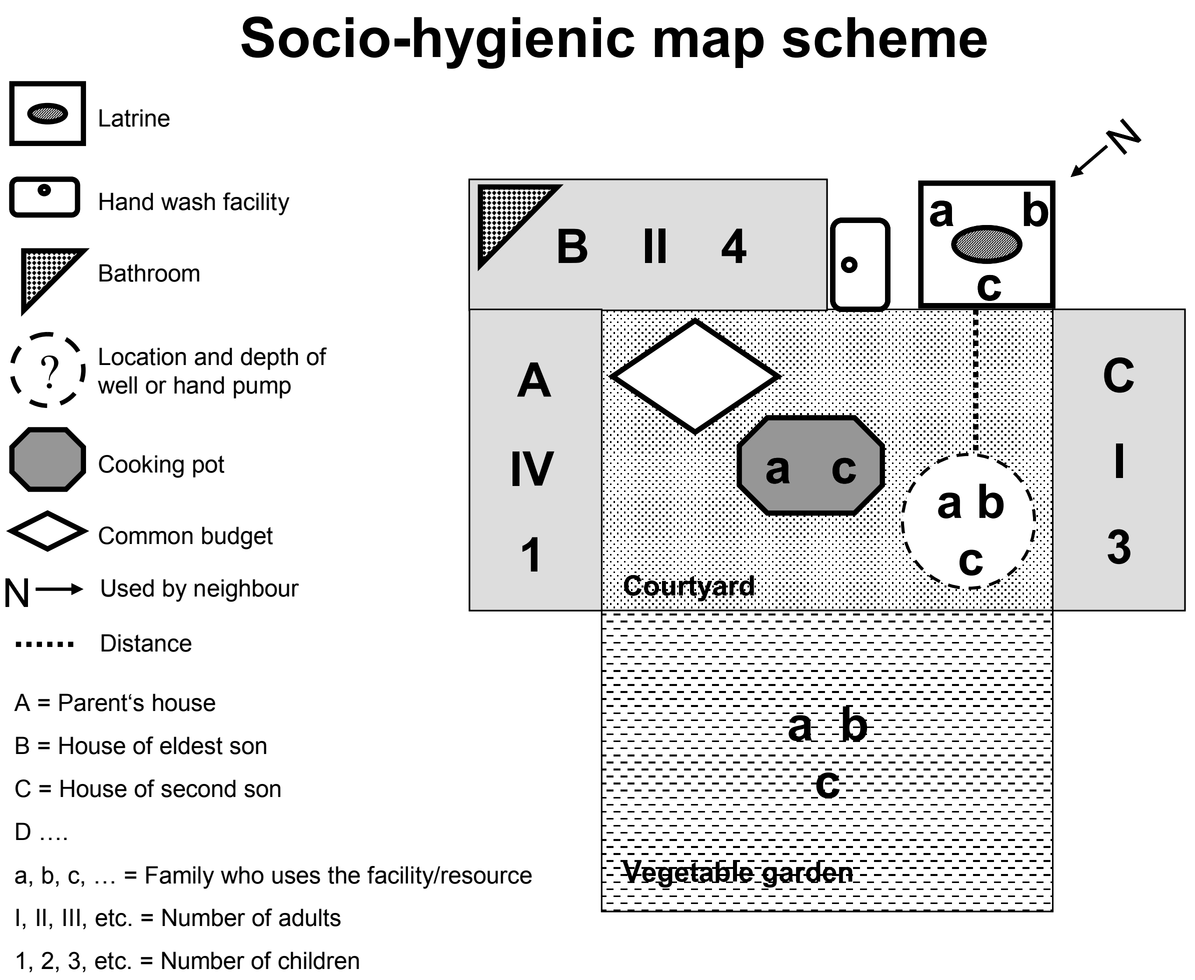

Figure 4.3 Socio-hygienic map scheme

4.4.7 Training of interviewers

The training of interviewers started with 18 candidates, but only 12 of them attended the entire training, which was a precondition for being selected. The pre-test of the questionnaire was included into the training phase; the field situation was also exploited to assess performance abilities of the interviewers. Potential interviewers were not paid for participation in the training; during the survey, fixed salaries were paid on a weekly basis.

After the pre-test, 5 students were selected as interviewers and 3 were put on the replacement list. All recruited interviewers were female students of the Urgench State University and ranged in age from 20 to 24 years. Their scientific background was rather different: two economists, two biologists, one geographer. All of them were native Uzbek speakers and fluent in the local dialect. Two interviewers spoke exclusively Uzbek; two spoke Uzbek and at least one other language on an intermediate level (Russian, English, German). Three interviewers had already worked in a survey on health economics in winter 2003. Furthermore, a data operator, an interpreter and a person for data check was selected from the training group.

The language of instruction was Uzbek delivered by sequential translation from English. The training lasted four to six hours a day for a period of two weeks. It was important that the interviewers during the interviews not only simply asked questions, but also understood the background of their tasks. Therefore, scientific data requirements as well as different methods and the criteria of evaluation used in the survey were taught and discussed. In order to familiarize the interviewers with participatory methods, the training was carried out using several participatory methods in an alternating way, changing every 45 minutes. As an incentive for the interviewers to conscientiously work until the end of the survey, weekly English lessons were offered free of charge to the team. At the end, the interviewers received a certificate containing training subjects and individual references.

The training scheme comprised subjects such as: requirements for scientific data collection, introduction into participatory methods like interviews, spot checks and socio-hygienic mapping, background information on diarrheal disease, drinking water supply, household drinking water storage, drinking water consumption and waterborne disease, health seeking behavior, home hygiene, personal hygiene, sanitation, child care as well as preparation and consumption of food. Guidelines for behavior during interviews, comprehensive role plays of interview situations and tests were further elements of the training. Over the entire survey period, interviewers were re-trained weekly on general survey rules and forthcoming tasks.

Strategies for interviewers how to handle upcoming problems with the survey households were a relevant issue over the entire survey period. The author of the present study and Dr. Dilorom Fayzieva – as facilitators of the training – agreed on the point that a common strategy of dealing with problems in Central Asia is ignoring them or sitting them out. This caused a heavy concern that non-reporting of problems with the households by the interviewers could result in refusal by the households to further participate in the survey, which would affect the outcome of the study. So, firm handling of problems was also a subject for several discussions with the candidates. Being aware that this is related to the cultural background of the individual and cannot simply be switched off, dealing with problems and discussion of problem cases was addressed by the author of this study regularly. It was repeatedly pointed out that problem reporting does not imply incompetence of the interviewer, but shows a sense of responsibility. Timely reporting of a problem offers the possibility to tackle it early enough. With this aim, interviewers were encouraged not to hide upcoming problems with the survey households, but to report them immediately.

Before the follow-up study in February 2004, a one-day training was conducted in order to refresh the knowledge of the summer training.

4.4.8 Supervision of the study

Before supervision of the study started, it was introduced to the *mahalla* heads before the beginning of the study. The responsibility of a *mahalla* head in an Uzbek community is similar to a mayor, but on a very low local level. They act as ‘gate keeper’, which implies that they decide which activities within the community will be supported and which not. The community members respect and follow their requests and orders. Therefore, *mahalla* heads were asked for their permission to conduct the survey, and they were shown the list of households included in the random sample. Usually, the *mahalla* head then asked residents to guide the interviewers to the selected households.

For supervision, a daily briefing including a feedback of the day before was held every morning before field work. Diarrhea diaries were collected and new forms – needed for the respective day – were distributed. During the briefing, check lists were also distributed and reminders for the daily tasks were given by the author.

A team meeting attended by an interpreter was held weekly and was a platform for exchange of experiences and reporting of problems of the previous week. Possible problem solutions were discussed in the team and a strategy for problem solving was chosen. If necessary, the training for the forthcoming tasks was repeated.

Daily supervision in the field was carried out by an interviewer, who was instructed to check whether all households in the respective area had been visited before the team left for the next *mahalla*. Every visited household was marked, and if the interview was not possible, the reason was noted down.

As a rule, each interviewer visited the same 35 to 40 families each week. Exceptional changes were allowed due to time constraints and personal problems between interviewer and household individuals. Interviews in the same region where the interviewer resided were avoided. Every interviewer was equipped with a folder containing forms, blank reserve forms, guidelines for behavior during interviews (see Appendix 9.9), official information sheets on the survey (see Appendix 9.10) and the address directory of all households included in the survey. They also carried a notebook and were encouraged to note additional information they regarded as useful for the study.

The survey followed a strict schedule, which coordinated the timing starting with the preparatory activities up to the management of the different tasks (Table 4.5). Tasks which could not be carried out in time, due to unexpected circumstances, were caught upon as soon as possible.

Table 4.5 Study schedule

Month	Week	Training	Diarrhea diary	Questionnaire	Spot check	Socio-hygienic scheme	Data check / entry
April	17						
	18		Pre-test	Pre-test			
May	19						
	20						
	21						
	22						
June	23						
	24						
	25						
	26						
July	27						
	28						
	29						
	30						
	31						
August	32						

4.4.9 Data entry and storage

The diarrhea diaries arriving daily were immediately checked and entered into the relational database (Access 2000®). Completed questionnaires were also entered, whereas incomplete questionnaires or questionnaires containing mistakes were returned to the respective interviewer for completion or clarification. Data entries were checked manually for completeness and automatically cross-checked via restrictions and queries. For every part of the study, an appropriate database was created. Finally, all data from different survey parts and all databases were unified in a single database.

4.4.10 Data processing

The results always refer to the same sample in summer (171 households, 1148 study participants) and in winter (173 households, 1172 study participants). Four households (nos. 10904, 11004, 11005, 40304) that filled in the diarrhea diary in less than 75% of the time (less than 9 weeks) were excluded from data analysis for the summer survey. Household 40104 was excluded due to permanent over-reporting in summer. According to the entries into the diarrhea diary of this household, several individuals of the household always suffered from diarrhea with fever. Moreover, the responsible interviewer reported several times that she did not trust the information given by this household. Dr. Wiesmann visited the household in June 2003 and confirmed that the family is very poor. Possibly the family hoped that over-reporting would lead to a monetary benefit.

In February 2004, 176 households participated in the 4-week follow-up study. Household 10902 was excluded from the analysis because less than 75% of the diarrhea diary was filled in. Two more households were excluded from the analysis: household 11010 because it moved to a different area and again the household 40104 for the reason of over-reporting. Three households – excluded in summer study 2003 due to the insufficient response – reported in the winter follow-up study more than 75% and were therefore included.

The age of the study participants using month and year of birth in June was calculated as the threshold for the age classification in June. For the division into age groups, it was considered that using the age in June 2003 minimised the possibility of misclassification for the summer study. For the follow-up study in February 2004, age in February 2004 was used as a deadline for the age calculation. If the date of birth was unknown to the individual, January was stated as month of birth.

The category 'others' was often chosen for some of the open questions. Here, the interviewers noted the answer. If entries in the category 'others' exceeded 5% of the total answers, the answers were subsequently coded (Friedrichs, 1990).

Contradicting information on drinking water source was found by triangulation and could be clarified by re-checking the questionnaire or re-visiting the households. In only a few cases could missing data sets not be clarified. Missing data were always entered as **-1** in all databases.

Data on education, housing, socio-economic status and income were obtained from the survey on health economics. Data analysis was carried out using MS Excel XP® and SPSS 12®.

4.4.11 Risk factor analysis

The possible risk factors for diarrheal disease on inter-household-level were analyzed using a multiple linear regression model: $y = \beta o + \Sigma\ \beta o\ xi + \varepsilon$

X_1 number of household (HH) members
X_2 number of weaned children in HH
X_3 distance between a house and its drinking water source in meters
X_4 number of children visiting kindergarten
X_5 number of hand wash facilities
X_6 household incomes in cash and in kind (in last month)
X_7 how many times per day drinking water is collected
X_8 how clean was the latrine/flush toilet (spot check 1)
X_9 how clean was the latrine/flush toilet (spot check 2)
X_{10} hygienic conditions of children's feces disposal
X_{11} frequency of pit emptying
X_{12} duration of left-over storage
X_{13} hygienic conditions of solid garbage management
X_{14} hygienic conditions of sewage management
X_{15} hygienic conditions of vegetable preparation
X_{16} frequency of drinking water treatment
X_{17} health care seeking behavior
X_{18} education of household head
X_{19} respondent's quality assessment of main drinking water source
X_{20} type of cleansing material available in toilet
X_{21} washing vegetables
X_{22} washing fruits
X_{23} washing salad, herbs
X_{24} washing strawberries
X_{25} washing mulberries
X_{26} preparing of meals in advance
X_{27} possession of refrigerator
X_{28} possession of washing machine
X_{29} hand wash facility situated close to toilet
X_{30} hand wash facility provided with water
X_{31} soap available during spot check
X_{32} towel available during spot check
X_{33} piped water as a main drinking water source
X_{34} dug well as a main drinking water source
X_{35} tube well as a main drinking water source
X_{36} possession of livestock
X_{37} pit latrine
X_{38} open defecation in household practiced
X_{39} any cleansing material in latrine/flush toilet available during spot check 1
X_{40} any cleansing material in latrine/flush toilet available during spot check 2
X_{41} urban *mahalla*
X_{42} visible contamination of stored drinking water during spot check 1
X_{43} visible contamination of stored drinking water during spot check 2

Because diarrhea episodes within households are not independent of each other, a household was chosen as a unit of analysis. The distribution of the dependent variable **number of diarrheal disease episodes per household** (n = 171) was left skewed. The natural logarithm plus one even carried out twofold did not change this distribution pattern substantially. For choosing the model and the pre-conditions, the newer statistical literature was followed, which shows that parametrical tests as analysis of variance (ANOVA) are robust against departures from normality or homoscedasticity (the standard deviation's equality of groups) (Moore and McCabe, 1999). A pre-test on the equality of variances, e.g., Levene's Test, should be avoided according to newer literature. Because multiple linear regression is a special case of General Linear Model (GLM), the same preconditions are valid for normality and homoscedasticity.

Diarrhea cases per family were regressed stepwise on 43 behavioral, environmental and socio-economic risk factors. For the hygienic conditions of the drinking water storage and the toilet or latrine, variables at different scales were generated. For this, data from triangulation methods as spot check evaluation of interviewers and objective observations were transferred into scores. In an exemplary fashion, this will be explained for the drinking water storage score.

The hygienic condition of drinking water storage vessels was evaluated by the interviewer as very clean, clean, dirty and very dirty. They were also checked for more objective evaluation criteria like visible contamination of stored drinking water, sediment on bottom of the vessel or coverage of the storage vessel. The number of respective items were added and divided by the number of summands to generate the score.

Toilets and latrines were also evaluated according to the categories as very clean, clean, dirty and very dirty. The objective criteria were presence of toilet paper or any other cleansing material, availability of water, soap and towel at a hand wash facility. Introduction of drinking water storage scores and toilet scores did not improve the model, therefore those variables were discarded.

The model was tested for robustness of estimates by repeated multiple regression analyses of random samples from the data base. For this reason, one and only person per household was randomly selected. The dependent variable – **the number of diarrheal disease episodes per individual** – was again left skewed. Collinearity between risk variables has not been detected neither in family wise nor in individual wise modeling.

4.5 Results

4.5.1 Response rate

The study on diarrheal diseases started with 189 households. The response rate for the monitoring of diarrheal disease in summer 2003 was 93%. Over the 3-month study period 5 households moved, 2 were permanently absent and 6 refused further participation (Table 4.6).

It was striking that out of the 6 households that refused further participation (10102, 10103, 10104, 10105, 10203, 40406) 4 lived in the *mahalla* Mustaqillik. Therefore, these households were visited by the author. As it was important to figure out the reason for the high refusal rate here, several attempts were made to communicate with the refusing household members. Unfortunately, owing to strong opposition this was not possible. The response rate for the 4-week winter follow-up in February 2004 was 99%.

Table 4.6 Response rate of diarrhea monitoring

	Non-response			Response				
				HH				
HH	**moved**	**absent**	**refused**	**No.**	**[%]**	**excluded**	**HH**	
189	5	2	6	176	93	5	**171**	summer
176	1	0	0	175	99	2	**173**	winter

HH = household

4.5.2 Community interviews

It is astonishing that in the brainstorming phase on urgent health problems, diarrhea was never mentioned by the participants of the community interviews. The disease categories were chosen by the participants themselves during the interview. All three communities or focus groups denied the question whether diarrhea should be included in the category of gastro-intestinal diseases (see 4.4.2). Asking for diarrhea in particular, the responders considered it mainly as a summer problem. After a discussion on diarrhea occurrence, the participants of the community interviews decided that diarrhea is a disease category in itself and should be added to the list of urgent health problems.

The health problem ranking resulted in a similar assessment of cardiovascular diseases by the mixed groups (Group 1 and 2). Both regarded cardiovascular diseases as the most important health problem in the region. Anemia and kidney disease were considered to be serious health problems by 12 to 14% of the interviewees. The assessment for the other disease categories rather differed (Table 4.7).

Table 4.7 Outcome of health problem ranking during community interviews

	Group 1		**Group 2**		**Group 3**	
	votes		votes		votes	
Disease category	No.	%	No.	%	No.	%
Blood/anaemia	9	12	9	14	4	11
Cardiovascular	18	25	16	24	0	-
Cancer	7	10	0	-	0	-
Diarrhea	4	5	9	14	4	11
Eye	7	10	0	-	0	-
Gastro-intestinal	12	16	4	6	9	24
Gland/goitre	7	10	6	9	0	-
Kidney	9	12	9	14	10	26
Neurological	0	-	5	8	0	-
Rheumatic	0	-	8	12	11	29
Σ	73	100	66	100	38	100

Contrary to the latter community interviews, the discussion with the females (Group 3) living in the pilot farm of the ZEF project showed that here different diseases were assessed as the most urgent health problems in the region. More than 79% of the women regarded rheumatic, kidney or gastro-intestinal diseases as the most urgent health problems. It was emphasized several times that socio-economic problems were more urgent than health problems. The women also stressed the extremely bad access to health care facilities, which had worsened over the last years. For many, even giving birth to babies, which had taken place for decades in the hospital, is not affordable any more. Therefore, the number of babies born at home is increasing.

An informal meeting was offered to the women, and they were promised a report about preliminary results at the end of the survey. The women appreciated this suggestion, but surprisingly nobody appeared when the meeting was offered, although the date of the meeting had been selected by the responsible interviewer (who knew about the habits and time constraints of the women) and had been announced in time.

4.5.3 Self-reporting of diarrhea (diarrhea diary)

Where general figures of summer and winter follow-ups differ only slightly, the winter figures are in parentheses next to the summer figure. The mean age of the 1148 (1172) participating individuals was 25.2 (25.3) years, ranging from 0.08 to 87.3 (0.08 - 82.6) years; 49.4% (49.6%) were males. Of the study participants 43% (42.5%) were from Urgench, 30.5% (30.5%) from Khiva and 26.5% (27%) from Kushkupyr.

By the end of the 12-week summer follow-up, information on 96,432 person-days was collected. For the 4-week winter survey, information on 32,816 person-days was obtained.

During the summer monitoring, 593 episodes of diarrhea occurred among 313 of the 1148 study participants. Of those participants with diarrhea, 139 (44%) experienced two or more episodes (range 2 - 8 cases per person). The mean duration of diarrhea in summer was 2.7 days for females and 2.9 days for males (Table 4.8). The children aged under two faced the highest burden of disease and suffered also from the longest duration of a single episode (3.1 days for girls and 3.7 days for boys less than two years old).

Among 103 of the 1172 participating individuals 127 episodes of diarrhea occurred during the follow-up in winter. Of those study participants with diarrhea, 18 (1.5%) experienced two or more episodes (range 2 - 4 cases per person). The mean duration of diarrhea was 3.7 days for females and 3.4 days for males (Table 4.8). However, for boys aged under two the mean duration of a single diarrhea episode was 1.9 days, for girls the respective number was 5.7 days. It was also found that in winter the mean duration of a single diarrhea incident lasted longer in all age groups (Figure 4.4).

Table 4.8 Diarrhea episodes and duration for 12-week summer and 4-week winter survey

	Males					Females					
		No. of		Mean			No. of		Mean		
Age	n	episodes	days	episodes	duration	n	episodes	days	episodes	duration	Season
< 2	22	32	117	1.5	3.7	31	71	220	2.3	3.1	**Summer**
2 - 5	39	17	52	0.4	3.1	45	27	52	0.6	1.9	
5.01 - 15	129	73	212	0.6	2.9	124	64	129	0.5	2.0	
15.01 - 60	342	113	317	0.3	2.8	339	166	501	0.5	3.0	
> 60	36	13	31	0.4	2.4	41	17	45	0.4	2.6	
Σ	**568**	**248**	**729**	**0.4**	**2.9**	**580**	**345**	**947**	**0.6**	**2.7**	
< 2	23	7	13	0.3	1.9	29	13	74	0.4	5.7	**Winter**
2 - 5	39	2	7	0.1	3.5	44	4	12	0.1	3.0	
5.01 - 15	135	18	59	0.1	3.3	126	13	50	0.1	3.8	
15.01 - 60	349	27	112	0.1	4.1	351	37	111	0.1	3.0	
> 60	36	3	5	0.1	1.7	40	3	14	0.1	4.7	
Σ	**582**	**57**	**196**	**0.1**	**3.4**	**590**	**70**	**261**	**0.1**	**3.7**	

Relationship of age and disease burden of diarrhea is shown in Figure 4.4. In summer, the disease burden peaked with 8.4 episodes/person per year for those aged under two, falling to 2.3 for children aged between two and five and further decreasing to 1.7 for the age group of the over 60 year-olds. Overall diarrhea incidence for children aged up to five years old was 4.6 episodes/person per year for the summer follow-up.

One infant born in December 2002, at the beginning of summer 2003 suffered from two diarrhea episodes (19 diarrhea days). Till the follow up in February 2004, the girl had died; the cause for her death was not reported to the interviewers.

In winter, the same trend for age distribution was determined with 5 episodes/person per year for the youngest age group and within a range from 0.94 to 1.55 episodes/person per year for the other age groups. For the winter follow-up, the overall incidence for children up to five years was 2.5 episodes/person per year.

In both seasons, diarrhea incidence peaked among those aged under two with a 41% decline in winter. Children between two and five years of age experienced 59% less diarrhea in winter. For the other age groups, the seasonal difference amounted to about 30%. Despite seasonality in occurrence of diarrheal disease, the person-time incidence shows high to very high figures for all studied seasons.

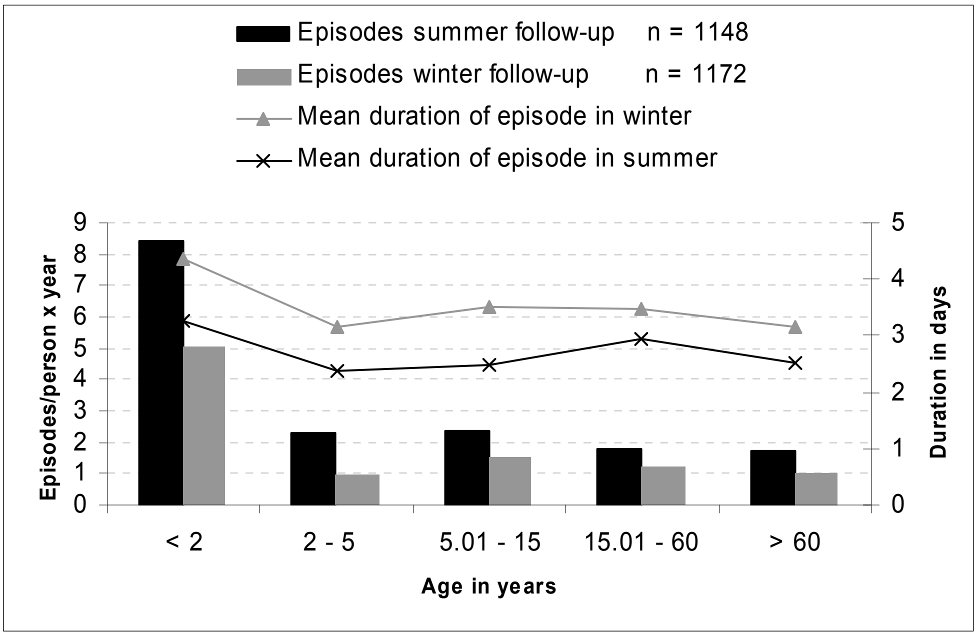

Figure 4.4 Person-time incidence year according to age strata

For the 12-week period in summer, the diarrhea incidence rate for Urgench with 21,656/100,000 per month was the highest followed by Kushkupyr with 20,000/100,000 per month. During this period, the monthly incidence rate for Khiva (13,404/100,000 per month) was the lowest.

Figure 4.5 demonstrates the weekly diarrhea incidence rates per *tuman*. For the onset of the study in May 2003, an incidence rate for the three surveyed *tumani* of 6,011/100,000 per week (ranging from 4,558 to 8,882/100,000 per week) was found. Over the 12-week monitoring period in summer, this overall incidence rate decreased to 2,613/100,000 per week varying for the three *tumani* within a range from 855 to 8,882/100,000 per week. The incidence rates for Urgench were the highest and those for Khiva the lowest.

Results for the winter follow-up show a decline for the overall incidence rate from 4,608 to 1,707 /100,000 per week. It is surprising that reported incidence rates for Urgench and Kushkupyr in February 2004 exceed the respective figures for August 2003, while figures for Khiva start on the same level as in August 2003. However, in the course of February, incidence rates for Urgench and Khiva decreased 2-fold, whereas the incidence rate for Khiva fluctuated around 2,000/100,000 per week.

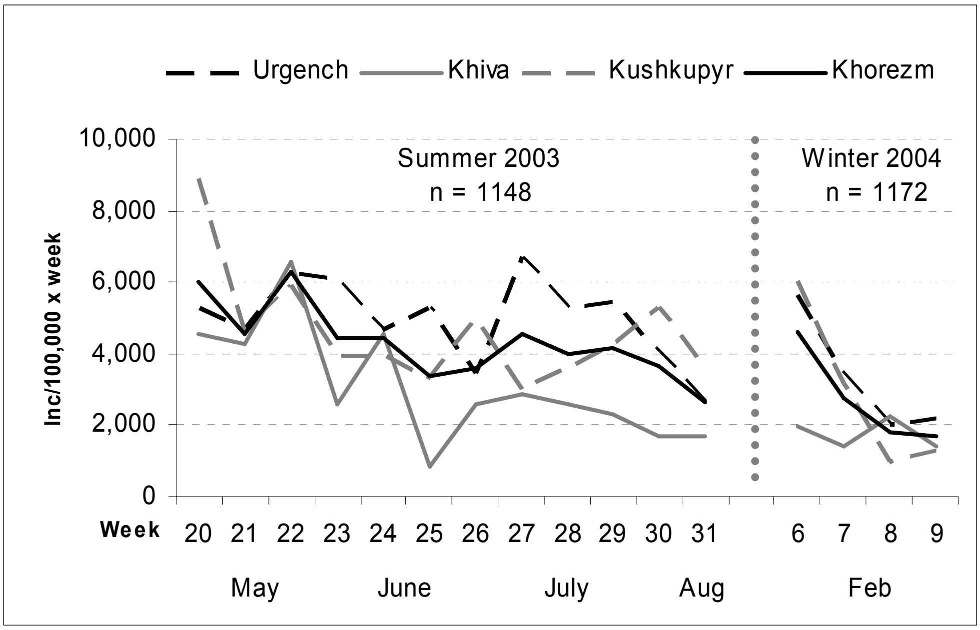

Figure 4.5 Weekly diarrhea incidence per *tuman*

Regarding urban and rural population shares of the sampled households, it was found that in the Urgench *tuman* 58% of the households lived in urban regions. In Kiva and Kushkupyr only 25% and 13%, respectively, of the households lived in urban areas. On the whole, the monthly urban incidence rate (17,301/100,000) was about 2,167/100,000 lower than the rural incidence rate (19,468/100,000) for the summer follow-up and almost balanced for winter monitoring (11,772/100,000 urban versus 11,760/100,000 rural). Analysing data according to the smallest administrative unit (*mahalla* level) and taking into account whether *mahallas* were classified as urban or rural, in 19 out of 23 *mahallas* incidence rates in summer exceeded those in winter.

In summer 2003, the highest incidence rates per month (up to 46,531/100,000) occurred in one urban and one rural *mahalla* of the Urgench *tuman*. For the Kushkupyr and Khiva *tuman*, the highest monthly incidence rates were reported for rural *mahallas* (Figure 4.6).

Surprisingly, incidence rates per month for two urban and two rural *mahallas* in winter exceed incidence rates in summer. However, for some of the *mahallas*, the number of participants was so small that results might be due to small numbers (see Appendix 9.8).

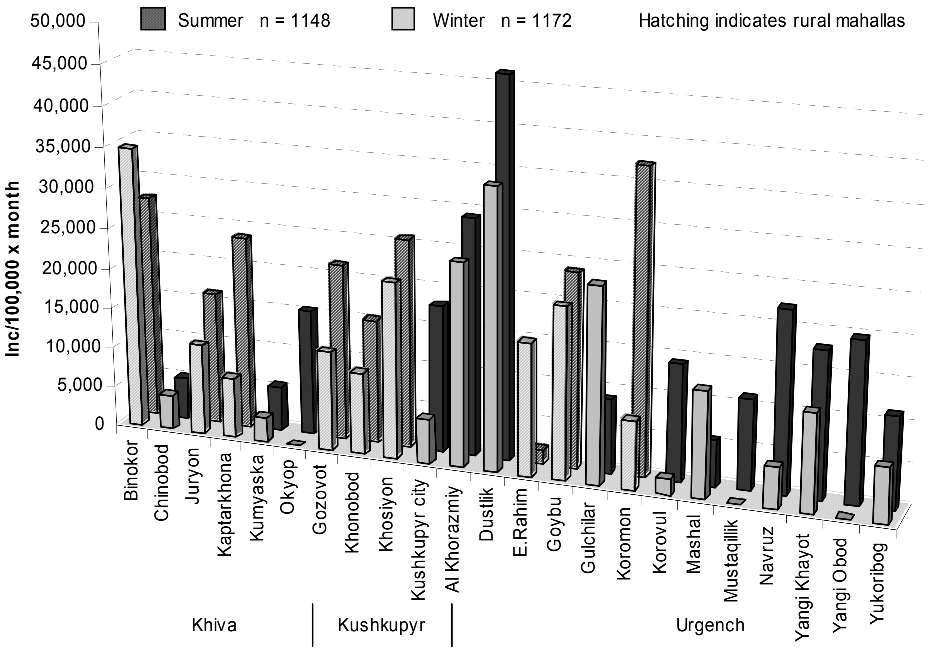

Figure 4.6 Diarrhea incidence/100,000 per month of urban and rural *mahallas*

Of the households, 49% used piped water as the main drinking water source, 37.5% relied on tube well water and 13.5% drew water from dug wells.

Regarding diarrhea occurrence according to the main drinking water source, in summer 2003 the incidence rates for piped water consumers ranged from 2,132 to 6,008/100,000 per week. In the 26th calendar week, the incidence rate for piped water consumers reached its minimum. Apart from the figure for the 20th calendar week, the population using dug well water as their main drinking water source had the lowest incidence rate. For the study population using tube wells, the incidence rate fluctuated between 1,099 and 12,088/100,000 per week. However, in the 26th calendar week all incidence rates ranged below 5,000/100,000 per week (Figure 4.7).

For the winter survey, weekly incidence rates according to the main drinking water source show a similar pattern to that of the incidence rates per *tuman* in summer. For all drinking water sources, incidence rates per week at the beginning of February exceeded levels in August and reached a more stable level at the end of the winter follow-up.

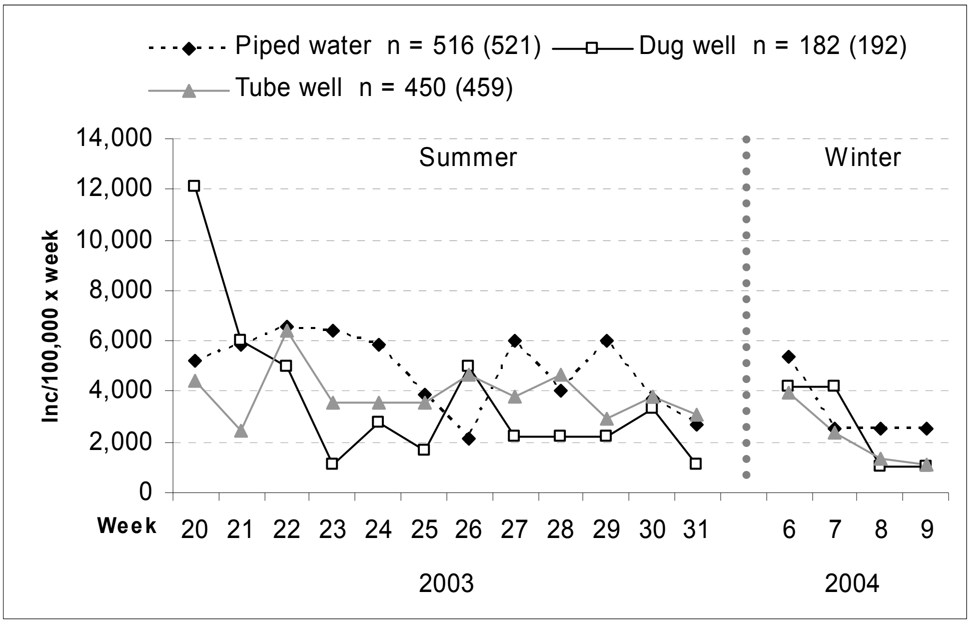

Figure 4.7 Weekly diarrhea incidence rates according to main drinking water source

4.5.4 Survey on exposure to risk factors

The average interview lasted 20 minutes (median). Differentiating the interview duration for interviewers, the duration ranged from 15 to 20 minutes. In 54% of the interviews, at least one additional person was present. Predominantly this was another member of the family (89%).

For open questions, multiple answers were possible, thus, percent of cases can account for more than 100%. Usually both, percent of cases as well as percent of respondents, are indicated. Due to the fact that 89.5% of the respondents were women, these numbers display predominantly the opinion of females.

Household drinking water issues

Surface and groundwater were utilized for drinking water purposes in the surveyed *tumani* of the Khorezm *viloyat*. According to local statistics, 47% of the population had access to piped water, which was met well by the random sample in which: 49% were served by piped water as their major drinking water source, 37% by tube wells and 14% by dug wells. Only households in the urban regions of Urgench city (74%), Khiva city (43%) and Kushkupyr city (8%) were connected to the piped water distribution system. They were mainly served by three water suppliers with treated surface water (see 2.5).

In the rural regions, mainly groundwater or shallow groundwater from tube wells and dug wells was utilized for drinking water purposes. This differed substantially for the three surveyed *tumani*. In the rural *mahallas* of the Urgench *tuman*, the households relied exclusively on drinking water from tube wells. In contrast, in the rural *mahallas* of Kushkupyr, 48% of households consumed drinking water from tube wells and 45% from dug wells (Figure 4.8).

Of the piped water taps 80% were located inside the house or yard and 20% outside the house or yard. Dug wells were mainly situated outside the house or yard (87%). Besides, tube wells were very often sited on the street (61%).

Additionally to the three main drinking water sources, one household practiced rain water harvesting for drinking and cooking purposes in spring. Other sources utilized for drinking and cooking were mentioned by seven respondents, but unfortunately not exactly indicated (Table 4.12).

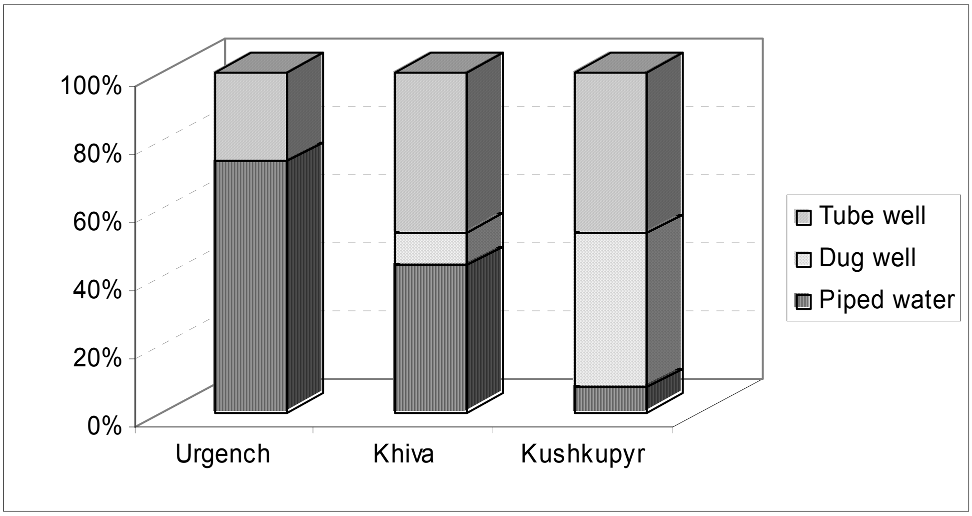

Figure 4.8 Share of drinking water sources utilized in surveyed *tumani*

Drinking water quality was assessed as equal in summer and winter by 52% of the respondents. Quality differences mentioned by the remaining 48% refer mainly to turbidity and salinity. As main criteria for quality assessment of drinking water the following were mentioned: cleanness, color, level of suspended solids (turbidity), salinity, taste and odor. For consumers of piped water, turbidity (50% of respondents) was the most important criterion followed by color (38%), cleanness (36%) and salinity (31%). Relying on dug wells and tube wells for drinking water supply, respondents regarded salinity (69%) as the essential criterion for quality assessment. Other decisive factors for this consumer group were color (31%), cleanness (30%) and turbidity (25%). The quality of the own drinking water source was assigned to the category 'good' by about 50% of the respondents and to 'not so good' 33%, while 15% had to rely on drinking water with a bad quality and only 2% used water of very good quality.

Availability of piped drinking water differed substantially between the seasons. Whereas for summer piped drinking water supply was reported as constant by about 54% of the households, in winter this was reported for the minority (14%) of the households) (Table 4.9).

Table 4.9 Availability of piped water in summer and winter

	Summer		Winter	
	Responses		Responses	
Category	No.	%	No.	%
Constantly	45	54	12	14
Periodically	24	29	69	82
Intermittendly	13	15	3	4
Never	2	2	0	0
Σ	84	100	84	100

87 system missing (well water) , 171 valid cases

The question whether respondents knew about the amount of drinking water used per day was answered in the affirmative by 71% of the respondents. The median for the estimated amount of dinking water per household per day varied substantially according to the main drinking water source: it was 10 L (range 1 - 40 L) for piped water consumers, 15 L (range 3 - 50 L) for tube well users and 20 L (range 4 - 45 L) for dug well users. Interestingly, the median amount of drinking water consumed per person per day varied even for the same water source when calculated from different numbers (answers) from the same respondent. **Amount A** is calculated on the basis of the amount of drinking water consumed per household per day. **Amount B** is derived from the frequency of water collections per day and the amount of water taken during each collection (Table 4.10).

Table 4.10 Amount of utilized drinking water per person per day

		Amount A	Amount B
Source	**n**	L/person/day	L/person/day
Piped water	52	2	5.5
Dug well	22	2.5	6.6
Tube well	63	2.5	7.8

Drinking water was collected for the most part by girls and women (78%) aged between 6 and 76 years (mean 27). Most frequently, water was collected three times a day (median 3, range 1 - 10). The median amount of drinking water drawn at one time was 15 L (range 3 - 85 L) and transported over a median distance – between a house and a drinking water source – of 15 m ranging from a few meters up to one kilometer.

Drinking water was almost exclusively transported manually (96%) and carried from the source to the household in uncovered buckets (96%).

According to the main questionnaire, the following figures refer to those 90% of the households that stored drinking water at least sometimes. The water was usually stored in buckets (88% of households) and only 15% of the households had a larger tank for drinking water storage. The fact that 154 respondents gave 221 answers to this question indicates that 43% of the households used more than one storage vessel type. Only 5% of the households used a storage vessel (jug, jar, kettle) that did not allow introduction of hands or dippers. Storage vessels were frequently cleaned by rinsing with water (65% of respondents), while about 30% of the households also used some type of detergent. The inside of the storage vessel was cleaned by rubbing it with the hand while rinsing by 6%.

Household drinking water treatment was practiced more often in summer than in winter. Overall, no household drinking water treatment activities were reported by 44% and 52% of the households, respectively. Measures applied to improve drinking water quality comprised boiling, settling and filtering or a combination of those activities. Responses show that households supplied by piped water practiced household water treatment more often than those using water from dug or tube wells (Table 4.11).

Boiling was the most frequent treatment for drinking water from all sources in both seasons. In summer, 51% of the households using piped water boiled their drinking water, while in the winter their share declined to 42%. For households using water from dug or tube wells, the portion of those boiling water decreased about 12% in winter.

Plain sedimentation or settling was also applied more frequently by piped water consumers. During the cold season, settling was less frequently applied by consumers of all water sources.

Filtration was only practiced by six households in summer and by two in winter and was therefore regarded as marginal (Table 4.11). Households practicing drinking water treatment did it always (71%), usually (17%) or only sometimes (12%).

Table 4.11 Seasonal differences in household drinking water treatment

	Summer			Winter		
		%			%	
Category	No.	Responses	Households	No.	Responses	Households
No treatment	76	36	44	86	46	52
Boiling	75	36	44	56	30	34
Settling	53	25	31	40	22	24
Filtration	6	3	4	3	2	2
Σ	210	100	123	185	100	112

0 missing cases, 171 valid cases

Consumption of unboiled water was very common, and 87% of the respondents' household members frequently drank unboiled water. Drinking of unboiled water at least sometimes accounted for 3%, while 10% of the respondents stated that consumption of unboiled water never occurred or that they did not know about it. The 21 respondents (12%) who stated that household members never or only sometimes drink unboiled water were questioned in detail about possible consumption of unboiled water. It turned out that members of the households which were declared as never drinking unboiled water, in fact consumed unboiled water on several occasions: at school, at work, in the field and more than 50% (12) on the street.

Table 4.12 shows that water for household needs was drawn from different and shifting water sources. Additional water sources like rainwater, surface water (*aryk*, channel, pond) and others were utilized for household needs. Mostly piped water (46%) as well as very frequently tube well water (41%) served for personal hygiene needs, e.g., a baths. Further water sources used for laundry and cleaning up purposes were rain and surface water. In order to keep the air in the yard free from dust in summer, the soil or ground was frequently sprayed with water. For this purpose, the water was taken from piped taps, dug wells, tube wells and from surface waters. Surface water (59%) was the most utilized water source for garden irrigation.

Table 4.12 Health-related use of different water sources for drinking and household needs

	Main water source		Drinking		Bathing		Laundry		Cleaning up		Watering the yard		Irrigation of garden	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Piped water inside	67	39	67	35	68	38	68	34	67	37	54	27	36	21
Piped water outside	17	10	19	10	15	8	17	9	15	8	23	12	20	11
Dug well inside	3	2	3	2	4	2	2	1	4	2	4	2	0	0
Dug well outside	20	12	20	10	19	11	21	11	18	10	16	8	1	1
Tube well inside	25	15	27	14	27	15	22	11	25	14	25	13	6	3
Tube well outside	39	23	48	25	46	26	42	21	46	25	42	21	5	3
Surface water	-	-	0	0	0	0	19	10	5	3	33	17	103	59
Rain water	-	-	1	1	0	0	6	3	1	1	0	0	0	0
Other	-	-	7	4	1	1	1	1	0	0	1	1	3	2
Σ	171		192	100	180	100	198	100	181	100	198	100	174	100

0 missing cases, 171 valid cases

Health and health-related behavior

For the previous five years, the respondents reported 21 male and 12 female cases of hepatitis (3% of study participants). The median age for all hepatitis cases was 9.3 years. Respondents were also asked whether they knew about the type of hepatitis the respective family member had suffered from. Exactly 50% of the cases were due to causes of hepatitis A and the other 50% were unknown. For the hepatitis A cases, the median age was 11.6 years. In the cases of unknown aetiology, the median age was 8.8 years after exclusion of one infant aged 5 months at the time of the survey. At this age, it is very likely that a neonatal jaundice was reported, and therefore the case was excluded from the analysis.

Of the respondents, 41% regarded microbes in drinking water as the reason for diarrhea. Consumption of fruits in hot weather or spoiled food was seen to be responsible for diarrhea by 28% of the respondents; unwashed fruits (25%) and bad food hygiene (11%) were other answers. Overall, 44% of the answers identified food as the cause of diarrhea. Lack of hygiene in general, poor sanitary conditions and dirty hands accounted for 12% of the responses. Sunstroke, insects, ecology, maternal milk, chemicals in drinking water, intestinal cold and other causes were mentioned in 16% of the answers (Table 4.13).

Table 4.13 Reasons for diarrhea

		%	
Category	No.	Responses	Households
Microbes in drinking water	70	20	41
Spoiled food	48	14	28
Consumption of fruits in hot weather	48	14	28
Unwashed fruits	42	12	25
Sunstroke	29	8	17
Lack of hygiene	20	6	12
Poor food hygiene	18	5	11
Poor sanitary conditions	15	4	9
Insects	11	3	6
Dirty hands	6	2	4
Ecology	6	2	4
Maternal milk	4	1	2
Chemicals in drinking water	3	1	2
Intestinal cold	3	1	2
Others	29	8	17
Σ	352	100	206

0 missing cases; 171 valid cases

The responses regarded as preventive measurements against diarrhea coincided well with those given as the causes for diarrhea. In the opinion of 68% of the respondents (29% of the answers) diarrhea could be prevented by washing fruits. Boiling of drinking water was seen to be a preventive measure against diarrhea by 61% of the respondents (26% of answers). Consumption of freshly prepared meals accounted for 16% of the answers. The sum of answers considering washing hands before cooking, before eating and after defecation was 8%. Breast-feeding, feeding infants with a spoon, boiling of nursing nipple and proper cleaning of children after defecation were mentioned in only 2% of the answers.

The treatment of diarrhea was similar for children and adults. For both – less often for children – the most frequent reaction named was taking pharmaceuticals (not specified) against diarrhea. Nearly 30% of the respondents relied on various herbal teas boiled from quince leaves or peel, pomegranate peel, mulberry leaves, camomile, dill and peach leaves. The third important treatment mentioned especially for children (25% of answers) was feeding rice gruel. Seeking health care in a hospital was more frequent for children than for adults.

Overall 47% of the respondents admitted to knowing nothing about oral re-hydration salts (ORS, brand-named Rehydron®), and 47% thought that it was a pharmaceutical against diarrhea. On the whole, differences in the knowledge about Rehydron® varied only slightly between the urban and rural population: 44% of the urban and 48% of the rural respondents knew nothing about Rehydron®, while 47% of the urban and 46% of the rural respondents regarded it as a pharmaceutical against diarrhea. However, 31% of urban respondents versus 21% of rural respondents knew that Rehydron® has to be prepared with boiled water.

The following marginal, 'traditional methods' (according to the participants) were recorded: eating eggs with pepper, soot or ash was practiced in 10 households but was less frequently used by children. Enemas applied contained, for example, pharmaceuticals, herbs and potassium permanganate ($KMnO4$). Traditional medicine also included eating of fruits from the djida tree (*Elaeagnus angustifolia L.*) and drinking various herbal teas. Methods mentioned as 'others' comprised non-fat food, spreading soot around navel and eating old bread, rice flour, unripe grapes and increase in amount of liquids (Table 4.14).

Table 4.14 Measures to cope with diarrhea

	Adults			Children		
		%			%	
Category	No.	Responses	Households	No.	Responses	Households
Pharmaceutical	127	45	74	103	33	62
Special herbal teas	47	16	27	47	15	28
Rice gruel	23	8	13	41	13	25
Hospital	22	8	13	28	9	17
Antibiotics	19	7	11	20	6	12
Egg	10	4	6	5	2	3
Enema	7	2	4	8	3	5
Traditional medicine	5	2	3	7	2	4
Boiled water	4	1	2	12	4	7
Stop feeding	3	1	2	3	1	2
Rehydron	3	1	2	19	6	12
Kefir	3	1	2	3	1	2
Black tea with sugar	1	0	1	2	1	1
Others	11	4	6	10	3	6
Σ	285	100	167	308	100	187

Adults: 0 missing cases, 171 valid cases
Children: 6 missing cases, 165 valid cases

The question on health care seeking was also an open question where multiple answers were allowed. Therefore, the numbers of each category are not equal to the total number of respondents (171). Occurrence of fever while suffering from diarrhea was mentioned as a reason for seeking health care 14 times (8% of respondents) for adults and 17 times (10%) for children. For about 60% of the respondents the duration of diarrhea incidence was a reason for seeking health care. Especially for children, a 2-day diarrhea was mentioned as a critical limit. Stool with blood, mucus or pus were also major reasons for health care seeking.

In 23% of the responses for adults and in 29% for children, fatigue, vomiting, serious pain and other symptoms were a reason for health care seeking, while 13% of responses for adults and 12% for children stated that diarrhea was not a reason for health care seeking at all (Table 4.15).

Regarding the question “When did a family member go to a hospital the last time?” 46% of the respondents could recall the number of days (range 1 - 48 days), 43% recalled the number of months (range 1 - 8 months), 8% referred to years (range 1 - 16 years) and 3% could not remember or did not go to the doctor at all.

The reason for the last health care seeking was suffering from at least one disease belonging to the categories: respiratory system 21%, gastro-intestinal system 18%, teeth 14%, urogenital system 11% and cardiovascular system 10%. The remaining 26% of answers referred to diseases of eyes and ears 6%, blood 6%, arms and legs 4%, vaccination and children’s disease 2%, endocrine system 2% and others 6%.

It was reported by 57% of the respondents that they always sought health care if needed, while 40% sought health care only sometimes, even if needed, and 11% stated that they never sought health care, and one respondent did not give an answer. For those who avoided seeking health care, the major objection was the cost of treatment (31%), while others showed mistrust towards doctors and services (13%).

Table 4.15 Reasons for health care seeking in case of diarrhea

		Adults		Children	
		Responses		Responses	
Category	Duration in days	No.	%	No.	%
Fever	> 1	3	21	5	29
	> 2	8	57	9	53
	> 3	3	21	3	18
Σ		14	100	17	100
Diarrhea	> 1	17	16	22	21
	> 2	38	35	44	42
	> 3	34	31	36	34
	5 - 6	13	12	4	4
	7 - 8	5	5	0	0
	> 8	1	1	0	0
Σ		108	100	106	100
Stool with blood, mucus, pus		53	64	46	59
Serious pain		5	6	6	8
Fatigue		5	6	8	10
Vomiting		4	5	4	5
Others		5	6	5	6
Don't seek health care		11	13	9	12
Σ		83	100	78	100

Child care

Of all households, 54% had children under seven, who were looked after by mothers in 84% and grandmothers in 16%. The number of meals served per day to children ranged from 1 to 6 with a median of 3.5. Out of 189 children aged under six, only 12 boys and 8 girls went to the kindergarten for 5 - 6 days per week; their median age was 4.1 years.

The median age of 47 breast-fed children was one year and ranged between 3 and 52 months. All children till one year of age and 77% of those aged under two were breast-fed. Only one child aged 11 months was exclusively breast-fed. Four children under the age of one did not receive additional food and two children in the same age group received no additional liquids except for mother's milk.

Weaning started on average at 6 months (range 1 - 24 months), but one infant started at 1 month, four infants at 3 months, four infants at 4 months and eight infants at 5 months.

Domestic hygiene

Matters of domestic hygiene were studied by the main questionnaire of the survey, additionally taking into account special spots in the house as more realistic direct indicators for overall hygiene conditions (triangulation). Spots regarded as indicators were: hand wash facility, drinking water storage and the latrine or flush toilet. The most common hand wash facility was a washstand (73%). This facility offers the functions of a washbasin, but its tank needs to be filled with water. The *kumgon* – a more simple facility consisting of a jar and a bowl – was used in 42% of the households. Since, all 171 respondents gave 211 answers, approximately 25% of the survey population used more than one hand wash facility type. According to the main questionnaire responses, 91% of the hand wash facilities were always supplied with water and 78% were always supplied with soap. Almost all respondents (99%) stated always to wash their hands before preparing food. Children's median hand wash frequency was reported as five times per day (range 2 - 10).

Solid waste disposal was managed by public (22%) and private (8%) services. Other common methods of solid waste management were burning (14%), littering in the environment (24%) and unofficial dumping grounds (13%), throwing into surface waters (14%) and other marginal practices (5%). At least 70% of the solid waste is, thus disposed of by unsafe practices causing pollution of the environment.

Food hygiene

Vegetables, lettuce and herbs were usually washed before consumption (98% of households). Strawberries were always washed in 45% of the households and sometimes washed in 15% of the households. Mulberries were eaten very frequently in spring and washed regularly only in 15% of the households.

Vegetables were mainly cleaned and prepared on a kitchen table (60% of respondents). In 26% of the respondents' households, vegetables were prepared on the kitchen floor and in 9% of the households in the yard, while 11% stated that a special bowl was used for vegetable preparation.

Preparation of meals in advance, e.g., soup, took place regularly only in 9% of the households, while 91% regularly used left-overs, which were kept covered by 59% and in a cool place by 83% (refrigerator 77%). The majority of households (74%) indicated duration of left-over storage as less than 12 hours, 25% stored meals between 12 and 24 hours and only one household for longer than 24 hours.

Sanitation

Only 12% of the survey households were connected to a public sewerage system. About 25% discharged their domestic waste water (sullage) by self-constructed pipes to the environment; exact places were not indicated. A lot of sullage (50%) was disposed in gardens, normally in a dug hole, and 11% of the sewage was discharged directly into surface waters like channels, ponds, *aryks* and drainage systems.

In 88% of the survey households, pit latrines (Figure 4.9) were used, of which 45% had concrete slabs. Pits were emptied by 78% of the survey households at least once a year. Most commonly (68% of respondents), the fecal sludge was dug out by own labor. Different pit emptying services were requested by 27% of respondents. Flushing out latrines by diverting surface waters into the pit was reported for 6% of the households. The most common ways of fecal sludge deposition were burying it in the garden (50% of respondents), using for the vegetables in the garden (22%) or depositing it onto agricultural land (12%).

For defecation of children aged under four (median), potties were used in about 50% of the households. In the remaining households, open defecation was common for kids under four, while 50% of the survey households deposited children's feces via latrine or flush toilet, 25% buried it in the garden and the other 25% practiced open deposition in the garden.

Figure 4.9 Simple pit latrines, the typical sanitation facility in rural Uzbekistan

4.5.5 Spot checks

Household drinking water storage

The results from two spot checks of the household drinking water storage vessels are consistent. Between 75% and 78% of the survey households stored drinking water in the period between May and July. The majority of the households stored drinking water in the kitchen and less than 20% outside the house. Buckets, as the most common storage vessel, were used in at least 76% of the households. Pots or other vessels were very frequently used as an additional storage vessel. Almost all vessels allowed the introduction of hands and short handled dippers, which were used to draw the water.

In general, 60% of the storage vessels were covered. Visible contamination caused by leaves, insects, sand and other particles was observed in 35.5% of the storage vessels. A sediment layer was found at the bottom of the vessels in more than 50%. The drinking water storage and its location were evaluated in 60% of the households as very clean or clean (Table 4.16).

Table 4.16 Results of spot checks of household drinking water storage

		First spot check		Second spot check	
		Households		Households	
Criteria		No.	%	No.	%
Drinking water storage	yes	128	75	134	78
	no	37	22	25	15
	sometimes	6	4	12	7
Inside the house	kitchen	116	87	116	85
	other	9	7	0	0
Outside the house	yard	9	7	17	13
	other	0	-	4	3
Storage vessel	bucket	112	84	103	76
	pot	30	23	35	26
	others	52	39	51	38
Critical control point	vessel covered	115	88	100	74
	visible contamination	46	35	49	36
	sediment	69	51	80	59
Interviewers' evaluation	very clean	25	19	21	16
	clean	117	89	117	87
	dirty	41	31	42	31
	very dirty	4	3	6	4

0 missing , 167 valid cases

Table 4.17 Results of spot checks of latrines and flush toilets

		First spot check		Second spot check	
		Households		Households	
Criteria		No.	%	No.	%
Cleansing material	not available	63	38	52	31
	paper	88	85	88	77
	cloth or cotton	9	9	13	11
	soil	7	7	12	10
	other	0	-	2	2
Used paper deposit	no bin	54	33	63	38
	open bin	99	60	98	59
	closed bin	12	7	5	3
Bin filling level	not full	69	63	49	48
	full	40	37	54	52
Interviewers' evaluation	very clean	5	3	6	4
	clean	43	26	36	22
	dirty	71	43	78	47
	very dirty	48	29	47	28

4 missing , 167 valid cases

Latrine or flush toilet

Three households were excluded from the analysis, because they had no own sanitation facility. Another household was excluded, because open defecation in the garden was practiced as long as construction of a new latrine was not finished. Both spot checks of latrines and flush toilets provided similar and consistent results. Some cleansing material was available in 62% to 69% of the surveyed households. Among those households, the most common anal cleansing material was paper of different types, like toilet paper (10%), newspaper or books (43%). Other materials were rags, cotton, soil and water. Used paper was deposited in a bin next to the latrine or flush toilet and frequently kept there till the bin was full. Over 70% of the households disposed of used toilet paper by burning it; other ways of disposal were throwing it into the latrine or via the solid waste.

According to the evaluation of the interviewers, only 25% to 29% of the latrines or flush toilets were assessed as clean or very clean, but 71% to 75% were categorized as dirty or very dirty (Table 4.17).

Hand wash facility

The hand wash facilities were checked only once during the second spot check. It was observed that 30% of the hand wash facilities were situated close to the latrine or flush toilet. Most of them were provided with water (90%) and 43% with soap and a towel.

4.5.6 Socio-hygienic scheme

According to the household roster used for the diarrhea diary, the mean household size was 6.7 individuals (range 1 - 20), 5.9 in urban and 7.2 in rural *mahallas*. The mean family size was 4 (range 1 - 8) individuals per family. Household and family composition and size were cross-checked by social mapping (triangulation).

It was found that the number of household individuals reported to the household roster and the number given during the social mapping differed in 17 households. For 10 households, the difference was only one person. Most differences could be explained by temporary absence or presence. Relations between families in Uzbekistan are so close that it is common to live temporarily with relatives for different reasons. So a respondent may have reported a 'temporary guest' as a family member during the mapping, but did not report this person to the household roster or vice versa. To only four households with different household size – between 3 and 9 persons – the UN household definition (see 4.4.6) was not applied properly. This means that those multi-family households were not completely included in the survey, in spite of common budgets or cooking pot.

In 79 households (46%), there was only one single family, and 92 households (54%) consisted of multiple families or extended families, which lived together with at least one more family. The number of families living together ranged from two to five. Out of the 92 households which lived in close community with other families, 93% had a common budget, 95% a common cooking pot and 91% a common plot of land where they grew vegetables and fruits. Here, due to the UN definition, two households were misclassified, because they had neither a common budged nor a common cooking pot, but were included as one household.

As the domestic hygiene can be assessed based on the hygienic condition of hygiene facilities like bathroom, hand wash facility and latrine or flush toilet, those facilities served as domestic hygiene indicators (see 4.4.5). In 58% of the households, there was no operating bathroom. Where a bathroom existed, on average 5.9 (mean) individuals shared it. A latrine was available in 85% and a flush toilet in 11% of the households, while 4% of the households owned neither a latrine nor a flush toilet but had to use public or neighbors' latrines or toilets. Hand wash facilities were reported for 96% of the households.

In total, 24 dug wells and 84 tube wells were in use for drinking water purposes and household needs, including watering of animals. The median depth of the dug wells was 7 m and the median age 20 years. The median depth for the tube wells amounted to 10.5 m and the median age to 5 years.

The safety distance between latrine and drinking water source is recommended to be at least 15 m (Cave and Kolsky, 1999) and 2 m above groundwater level. In 8 of 108 households, the distance between latrine and water source was less than 15 m and in 2 even less than 10 m.

Risk factor analysis

Table 4.18 shows the results of the multiple linear regression analysis. The multivariate linear model demonstrates association between the number of diarrhea episodes per household and the following exposures: availability of cleansing material in the latrine or toilet (relative risk = 1.2, 95% CI = 1.01 - 1.48) and visible contamination of stored drinking water (relative risk = 1.1, 95% CI = 0.89 - 1.41). Both are dummy variables and highly significant. The comparable impact of the respective variable for the model is expressed by the standardized beta coefficient (β*). The algebraic sign of the beta coefficient indicates the type of association. A negative algebraic sign means: the smaller the value for the respective factor the higher the diarrhea incidence per household. A positive algebraic sign shows that the higher the value for respective factor the higher the diarrhea incidence per household.

For the availability of cleansing material, the negative beta coefficient indicates that the absence of cleansing material is associated with a higher number of diarrhea episodes for the household. For visible contamination of drinking water, the positive number (β*) indicates that visible contamination is associated with a higher number of diarrhea episodes for the household. Residuals are distributed normally or close to normal. Durbin-Watson Test results ranging around two indicate absence of autocorrelation (Bühl and Zöfel, 2002), which holds for all tests.

Statistical simulation has proven robustness with regard to factors, significance and direction (algebraic sign). Again, availability of cleansing material and visible contamination of stored drinking water were very important. Availability of cleansing material is significant in four and visible contamination of stored drinking water in three out of five random samples. The Durbin-Watson test, β*, R^2 and standardized residuals are within the same range.

During the simulation, other factors appeared to be associated with the occurrence of diarrhea. Those are mainly: frequency of drinking water collection, hygienic conditions of children’s feces disposal and possession of a refrigerator. Households without a refrigerator are associated with more diarrhea episodes. The same applies to unsafe disposal of children’s feces and frequent collection of drinking water. Without testing for robustness, those factors appearing less frequently appearing factors could have been the final results. This outcome emphasizes the need for the usually not practiced but highly important validation of regression models by statistical simulation. Nevertheless, it points to the role that these factors also play in hygiene.

Table 4.18 Results of risk factor analysis for diarrheal diseases

	HH		Random 1		Random 2		Random 3		Random 4		Random 5	
N	142		142		142		142		142		142	
R^2	0.109		0.101		0.185		0.102		0.146		0.185	
Durbin-Watson test	2.038		2.199		2.023		2.040		2.242		2.023	
	β*	p	β	p	β*	p	β*	p	β*	p	β*	p
Any cleaning material in latrine/toilet available during spot check 1	-0.243	0.003			-0.224	0.005	-0.170	0.038	-0.282	0.000	-0.224	0.005
How many times per day drinking water is collected					0.165	0.040					0.165	0.040
Hygienic conditions of children's faeces disposal							0.293	0.010				
Visible contamination of stored drinking water during spot check 1			0.166	0.42								
Visible contamination of stored drinking water during spot check 2	0.245	0.003			0.282	0.000			0.282	0.000	0.282	0.000
Refrigerator			-0.294	0.000								

HH = household

4.6 Discussion

4.6.1 Diarrhea and the risk factors water, sanitation and hygiene

During the community interviews, it became evident that diarrhea is not perceived as an important health problem among the population in Khorezm. In contrast, data from the active diarrhea monitoring show weekly diarrhea incidence rates ranging between 2,600 and 6,300/100,000 population for Khorezm, which implies that 2,6 to 6,3% of the population contract a diarrheal disease weekly (see Figure 4.5), and that the incidence of diarrhea is rather underestimated. In spite of this, people have concepts about what the causes of diarrhea are and what kind of treatment is necessary. Diarrhea is perceived as a health problem that occurs only in summer. Data show that for the majority of the people, diarrhea is related to microbes in drinking water or associated to consumption of fruits, especially when it is hot. Halvorson (2004) and Bentley (1988) found that exposure to heat was related to diarrhea by respondents also in Pakistan and India. These hot-cold concepts might even stem from the teachings of Avicenna (Ibn Sina, *980 Buchara, †1037 Isfahan), who – in present Uzbekistan – influenced the development of oriental medical knowledge.

It is striking that even similar descriptions were used by Pakistani and Khorezm respondents regarding the reasons for diarrhea namely: dirty, spoiled, imbalanced and unsuitable food. The causes assumed to be responsible for diarrhea in Khorezm were for the most part related to food. This is also reflected by the knowledge about prevention strategies that are mainly related to food hygiene.

Other hygienic needs, as hand washing, seem to be neglected. A study conducted by Huttly et al. (1987) has proven that the absence of soap constitutes a risk factor for diarrheal disease. Proper hand washing has been documented to be the key factor in disruption of the fecal-oral transmission route. Many intervention studies promoted hand washing before food preparation, after using the toilet and after contact with children's feces (Curtis et al., 2000; Curtis et al., 2001; Gibson et al., 2002; Luby et al., 2004; Luby et al., 2001).

According to a meta-analysis of 17 studies, Curtis and Cairncross (2003a) estimated that proper hand washing could reduce the diarrhea risk by 47%. At a first glance, hand washing both after defecation and before handling food or liquids, and before feeding, etc., seems to be the same tactic in combating fecal-oral disease transmission. In fact, it has to be attributed to two different prevention strategies: and washing after contact with fecal matter acts as a primary barrier, whereas hand washing before food preparation and eating is a secondary barrier (Curtis et al., 2000).

Manun'Ebo et al. (1997) found that hand washing frequency tends to be over-reported when gathering information on that issue by the use of questionnaires. Indeed, all respondents of the present study answered the questions "Do you wash your hands after using the toilet?" and "Do you always wash your hands before preparing food?" affirmatively. Continuous presence of soap at the hand wash facilities was indicated by 78% of the respondents.

In order to gain insight into the real situation on this issue, a triangulation was used. It turned out that soap was approximately half as often present as indicated during the interview. Those results clearly show that people are familiar with hygiene strategies like 'when' and 'how' they 'should' wash their hands, but that there are also discrepancies between knowledge and practice. Most (70%) of the hand wash facilities are located away from the toilet, which makes it hard to follow proper hygiene habits and to interrupt the primary transmission route. A study conducted in Burkina Faso (Curtis et al., 1995) showed that mothers living in households with a water source on their premises are more likely to wash their hands at critical moments.

Another important factor in fecal-oral disease transmission is the lack of improved sanitation and its implications. The population in Khorezm has at least basic access to sanitation, but a huge share is unaware of health hazards and environmental pollution due to hygienically unsafe sewage discharge, excreta and solid waste management.

The vast majority of the surveyed households (88%) practices on-site sanitation by means of simple pit latrines. Only households equipped with a flush toilet are connected to the public sewerage system. On-site sanitation facilities can create hazards to personal and public health via groundwater contamination and unsanitary conditions. Unhygienic sanitation facilities contain high fecal-oral pathogen loads posing a high risk of infection of its users. Moreover, desludging – predominantly carried out by family labor – is a risk of infection for those involved in this work. Spot check evaluation of sanitation facilities showed that unhygienic conditions occur frequently, e.g., dirty latrines and used toilet paper in open bins, which again hold a risk of infection for the person who has to empty them.

The incidence of diarrhea in children living in neighborhoods with drainage and sewage is about 60% lower than in those without (Moraes et al., 2003). Hoque et al. (1999) even observed associations between conditions of latrines and death through diarrheal diseases. In Khorezm, the number of households found to have dirty to very dirty sanitation facilities was surprisingly high (35%). Oldham (2000) found even worse hygienic conditions of school toilets and elaborated a participatory health hygiene education program for schools and communities in Khorezm, aiming at habitual changes as a basis for the optimization of long-term health benefits from water supply and sanitation interventions.

The application of human excreta to maintain soil fertility has been practiced in Eastern Asia and the Western Pacific for 4000 years (Mara and Cairncross, 1989). On the one hand, nutrient recycling offers monetary and ecological benefits, especially to economically and ecologically stressed regions. On the other hand, application of human excreta to agricultural land without adequate treatment exposes the population to a variety of bacterial, viral, protozoan and helminthic diseases (Feachem et al., 1983). Depending on the crops grown and the time span between application and consumption of the product, a substantial fecal contamination is possible. Therefore, nutrient recycling from human excreta, especially feces, has to follow management strategies preventing fecal contamination of fields, crops and receiving water bodies, which in turn reduces fecal-oral disease transmission. Here, it is most important to sanitize the feces either by dehydration or decomposition (Winblad, 2000).

In Khorezm, hygienically unsafe nutrient recycling of human excreta is common. About 30% of the responding households apply human excreta directly to the vegetable garden or agricultural land; another 50% use safer nutrient recycling practices and bury human excreta close to trees or somewhere else in the garden. In Vietnam, a market-based project on sanitation for the rural poor increased access to sanitation by about 100% within one year. Here, the driving factor for the poorest was the use of compost from human excreta as fertilizer (Frias and Mukherjee, 2005). As social acceptance of nutrient recycling is high, it seems to be a good starting point for the implementation of ecological sanitation (ecosan) in Khorezm. Because of the very low awareness of associated health risks (Oldham et al., 1999), accompanying health hygiene education is essential.

Furthermore, the open disposal of children's feces (25% of households) and frequently open defecation of children (50% of households) contribute to an environment loaded with fecal-oral pathogens. Children's feces constitute a significant reservoir of agents causing diarrhea (Esrey et al., 1985). Therefore, unsafe deposition of childrens' feces is followed by contamination of houses, yards, gardens and the neighborhood, posing a major health risk to dwellers, their neighbors and visitors. Unsafe disposal of children's feces was associated with a higher number of diarrhea episodes per household in one of the validation analyses conducted for the multiple linear regression model. Overall, a fundamental lack of knowledge about interrelationships between sanitation, drinking water quality, health and their implications triggers unhealthy habits in the Khorezm region.

Although an association between food hygiene at home and diarrheal diseases could not be proven, some aspects concerning food hygiene need to be elucidated. As explained above, inappropriate fertilization of crops with human excreta or waste water irrigation are the foremost sources of foodstuff contamination. All foods are contaminated by various microorganisms to a certain extent, but the level of contamination depends on the type of food and food handling practices of handlers and consumers (Black, 2001). Food can be contaminated before reaching home, at home, uncooked and cooked due to improper handling or storage. Normally, washing of vegetables or fruits is expected to decrease contamination, but using polluted water can even increase microbial contamination of food (Heller et al., 2003).

Washing of vegetables was reported by almost all respondents, while washing of fruits was less frequent. Although detection of changes in microbial contamination of food is beyond the scope of this study, some basic information on hygiene during home processing was collected and introduced into the multivariate risk factor analysis. Cleaning of vegetables on the kitchen floor (26%) or in the yard (9%) is common. Together with the open disposal of children's feces it constitutes a hazardous habit. Uncovered meal left-overs on a stove can often be observed. In contrast, most respondents reported to keep left-overs covered in the refrigerator or a cool place.

However, a study conducted in Brazil associated the custom of food storage on a stove with enterotoxigenic *Escherichia coli* infections (Sobel et al., 2004).

The impact of both available drinking water quantity (Esrey et al., 1992; Lewin et al., 1997) and microbiological drinking water quality (Esrey et al., 1991; Roberts et al., 2001; Semenza et al., 1998; Trevett et al., 2004) on diarrheal disease and water-related disease incidence have been extensively investigated. A minimum of 20 L water per capita per day is needed to cover drinking, cooking and basic hygienic needs, but this amount is still associated with a high level of health concern (Bartram and Howard, 2003).

In Khorezm, the amount of drinking water used per household per day could not be reported by 29% of the respondents (see 4.5.4). Those who knew the amount of drinking water gave on average very low volumes. For cross checking, the questionnaire contained questions on the frequency of drinking water collection and amount taken during one collection. Although these numbers more than double the amount of water indicated by the respondents, e.g., from 2 to 5.5 L for piped water (Table 4.10), this still seems to be too little compared to other water-stressed regions.

Esrey et al. (1992) determined 8 L per capita per day as the average available amount in rural Lesotho. However, one could suspect that the question was not posed properly in the Uzbekistan case, but referring to numbers from recently installed watermeters, consumers used 10 to 15 L per household per day (Personal communication of Sachsenwasser, June 2004). This confirms the validity of the interview results and indicates that people reported only the amount of water that was ingested. Water for personal hygiene and other household needs was often taken from other sources, including highly polluted surface waters.

Concerning the microbiological quality of water for drinking water purposes and household water needs, it is important to distinguish source quality and POU quality. Even excellent source water can deteriorate during collection, transport, treatment and storage before ingestion or use for household needs. POU drinking water quality has even a higher impact on diarrhea outcome than source quality. This is confirmed by a 44% reduction of diarrheal disease after an intervention – in Bolivia – using the combination of: POU treatment, safe storage and community education (Quick et al., 1999). Nevertheless, further field studies about POU interventions are needed (Gundry et al., 2004; Sobsey, 2004). As much of the world's population stores water for different reasons, the respective hazards have to be considered carefully.

In Khorezm, the reason for household drinking water storage in rural areas is mostly the distance from the water source, whereas in urban areas it is the intermittent supply. The daily availability (hours) of piped water could not be indicated by urban respondents. Moreover, the irregular and intermittent supply leads to the storage habits of consumers in the affected part of the supply system. Deterioration of microbiological drinking water quality during storage, well recognized by several studies (Blum et al., 1990; Brick et al., 2004; Lindskog and Lindskog, 1988; Pinfold, 2003; Roberts et al., 2001; Trevett et al., 2004), is confirmed by the results of the sampling of drinking water in Khorezm in this study.

In order to mitigate problems arising from household drinking water storage, the WHO (Sobsey, 2004) recommends the application of the hazard analysis critical control point concept (HACCP) for household water storage. In the context of the Water Safety Plan, those critical control points (CCPs) comprise: source water quality, household water collection, treatment, storage and use. More specific CCPs for household water treatment and storage are: vessel type, vessel integrity and vessel sanitation. The preferred vessel design comprises among other criteria a narrow opening, not allowing introduction of hands and dippers. Its integrity is categorized into 'intact' and 'not intact' due to scratches, cracks, leaks. The sanitary status of the vessel considers cleaning method and frequency.

Some of the CCPs and key hazards, which could be identified by this study, are summarized in Table 4.19. The hazards and CCPs described here are not intended to be comprehensive or complete. In order to ensure high source water quality, water safety plans (WSP) could also be developed and implemented for dug wells and tube wells (Howard, 2003).

Table 4.19 CCPs for household drinking water storage in Khorezm

Drinking water	CCP	Hazard
Source	protection	often no apron, safety distance violations (latrine, vegetable garden), dug wells have no cover, tube wells equipped with hand pump allowing contamination
	microbiological quality	faecal contamination in all sources
	chemical quality	high nitrate levels in tube wells and dug wells
	desinfectant residuals	beyond detection level for piped drinking water from municipal supply
	turbidity	highest for piped tap water
	salinity	high for tube wells and dug wells
Collection	technique	contamination of source by pouring water into the hand pump for initialisation of vacuum
	transport vessel design and integrity	contamination of transport vessel by touching vessel inside
Storage vessel	design	wide opening, no cover, no outlet
	integrity	visible contamination
	sanitation	cleaning of vessel insufficient
Treatment	use of best available source	inadequate temperature and/or duration, infrequent
Use	ladling	introduction of hands and short handled dippers, frequent consumption of non-boiled water

Strategies for hygienically safe household water treatment to improve the microbiological quality of drinking water are being developed worldwide. By means of simple, accessible systems such as appropriately designed storage vessels, home chlorination and solar disinfection, they are made affordable (Sobsey et al., 2003). The optimal composition and design for a storage vessel includes a chlorination-resistant material, a narrow-mouth with a valved spigot for dispensing water, and a handle. In 1998, an intervention study using appropriate containers and home chlorination was carried out in Karakalpakstan, Uzbekistan (Semenza et al., 1998). The findings of this study revealed an 85% reduction of diarrhea for the intervention group chlorinating drinking water from wells, compared with those who did not chlorinate the water. Comparing the diarrhea incidence of the home-chlorination group with those having access to piped water shows a 62% reduction for the intervention group.

Home chlorination of drinking water with high salinity – as proven for wells in Khorezm – is thought to create a 'taste composition', which will not be accepted by consumers in the long run. However, the high number of sunlight hours (3000 - 3100 h/year) and the high total solar radiation in Uzbekistan (in flat areas 130 - 160 ccal/cm^2/year) could offer an alternative approach by application of simple solar disinfection systems. Locally produced low budget systems could offer microbiologically safe drinking water and opportunities for local enterprises.

Many variables concerning the above discussed and most studied environmental risk factors for diarrheal disease – specifically water, sanitation, breast-feeding, food and hygiene – were included to the multiple linear regression analysis. Of the many potential exposures related to these risk factors and examined in this study, two independent risk factors were identified: absence of anal cleansing material in the latrine or toilet and visible contamination of stored drinking water.

The association with anal cleansing material is similar to the findings of Semenza et al. (1998), who confirmed the use of toilet paper to be a protective factor. They found an absence of toilet paper in 43% of the households, which is comparable to the 47% in this study. However, the presence of any anal cleansing material and not the type of cleansing material was associated with less diarrhea cases per household.

4.6.2 Burden of disease and problems of scale

Hunt (2001) states that understanding of health impacts arising from risk factors suffers from methodological difficulties such as: use of different definitions, recall bias and the measurement of 'use' of services. A methodological problem – which the present study has revealed – is the risk factor 'maintenance status' of a facility. Usually, research on maintenance is focused on large-scale problems, like distribution systems. However, both risk factors associated with the number of diarrhea episodes per household in this study refer to the category 'maintenance on small-scale level'. The poor maintenance status, which caused unhygienic conditions, would have been undetected using just standardized questionnaires. The subjective evaluation of the hygienic status by the interviewers was also an insignificant risk factor, though the maintenance problem contributes to the overall hygienic status of the facility.

Distinguishing between 'improved' or 'unimproved' services and facilities as it is regularly applied for sanitation and drinking water supply can be confounded by its maintenance status, which can affect studies on a meta-level. The importance of maintenance is acknowledged for large scale systems, e.g., water distribution and sewage systems in industrialized countries, but often neglected in non-industrialized countries or for small-scale facilities. A concept, which cuts across different classifications of disease transmission and includes the small-scale level, addresses the role of public and private domains (Cairncross et al., 1996).

Data on diarrheal disease incidences for countries in the transition phase – especially in Central Asia – are scarce in the literature. The same is true for general data on diarrhea incidences for all age groups. Most studies focus on childhood diarrhea and apply pathogen-specific designs for adults and are not appropriate for an overall estimate. For this reason, outcomes from Khorezm will also be compared with median numbers for non-industrialized nations in the following part of the discussion.

Results from this study reveal that active surveillance tremendously increases the reported diarrhea incidence compared to officially passive registered cases. In July 2002, the monthly incidence rate obtained by passive surveillance peaked with 37/100,000 per month. In contrast, active surveillance found an incidence of 16,494/100,000 per month in July 2003, while a peak of diarrheal disease in July could not be confirmed. On the contrary, diarrhea incidence rates for Khorezm showed a decreasing trend over the course of the summer follow-up (see 4.5.3). Even if the higher incidence in the beginning of the survey were to be attributed to recall bias – because people might have observed their body more meticulously than usual – this would change the overall trend only slightly. A seasonality effect with higher incidence rates of 30%, but varying for the age strata, could be proven for the summer time.

Population-based estimates assess the overall incidence of diarrhea to 0.2 - 1.4 episodes/person per year for industrialized countries (Herikstad et al., 2002; Wheeler et al., 1999). A study conducted in Cherepovets, Russia, including all age groups found an incidence of 1.7 episodes/person per year, which coincides well with the 1.8 episodes/person per year for all ages found in Khorezm.

Age stratification reveals that the younger the person, the higher the burden from diarrheal disease. The global median incidence for the period between 1990 and 2000 is the highest among children under one year of age with 4.8 episodes/child per year, falling progressively to 1.4 episodes/child per year for the 4-year-olds. The global median number of episodes for all children under five is 3.2 /child per year (Kosek et al., 2003) ranging between 0.24 episodes/child per year in Thailand and 10.4 episodes/child per year in Guinea-Bissau.

Surprisingly, person-time incidence rates for children in Khorezm exceed median global estimates for non-industrialized countries. Estimates for mean person-time incidences have been carried out assuming 6-month summer and 6-month winter conditions. Thus, in Khorezm each individual under the age of two suffers on average from 6.7 episodes/child per year decreasing to 1.6 episodes/child per year for those aged between two and five. Comparing person-time incidence estimates for children aged under five in Khorezm and Karakalpakstan, the following can be stated:

1. In both regions the incidence is the highest for the non-piped water group;
2. The piped water group in Khorezm experiences 1.6 episodes/child per year more than in Karakalpakstan;
3. On average, a child under five in Khorezm suffers from two episodes more than a Karakalpak child (Table 4.20).
4. As the drinking water source was not associated with the incidence of diarrhea in the multiple linear regressions, analysis of these numbers might raise questions. However, results from the regression analysis refer to the inter-

household level and can therefore not explain diarrhea outcomes on the individual level.

Assessing the magnitude of diarrhea for Khorezm according to the estimated yearly person-time incidence rates, for children under the age of five and comparing with results from other countries, it is evident that the burden of diarrhea is tremendously high. The current personal and economic burden that the high incidence of childhood diarrhea imposes on the children's families is enormous, and might even be exceeded by the unknown long-term effects and costs of early childhood diarrhea.

Recent studies on the long-term effects of early childhood diarrhea have proven consequences such as growth faltering (Moore et al., 2001) and impaired physical and cognitive development in later life (Guerrant et al., 2002a; Niehaus et al., 2002). These facts demand for action in order to interrupt the vicious cycle of diarrhea, malnutrition and impaired child development (Lima and Guerrant, 2004). A needed assessment of costs due to childhood diarrhea is limited by the inability to use national statistics to identify the true mortality from diarrheal deaths and the fraction of these deaths due to waterborne infections. National data for Uzbekistan (14.5 deaths/100,000 children due to diarrhea) are the lowest among countries with a similar socio-economic development in the region (WHO, 2006).

Table 4.20 Childhood diarrhea in Khorezm and Karakalpakstan modified after Semenza et al. (1998)

Location	Study group	Total no. of children < 5	Total episodes	Episode/child x year
Khorezm summer 2003	non-piped water	77	93	5.2
	piped water	60	53	3.8
	all sources	137	146	4.6
Karakalpakstan summer 1996	non-piped water	80	80	5.4
	non-piped home chlorination	88	14	0.9
	piped water	176	72	2.2
	all sources	344	166	2.6

4.6.3 Treatment of diarrhea

The discussion of the epidemiological survey outcomes started with the perception of diarrhea in Khorezm and has addressed different risk factors associated with diarrhea and the burden of the disease. Finally, the loop will be closed with considerations on treatment issues with focus on the most vulnerable group, i.e., children. According to a study in Brazil, caretakers habitually treat childhood diarrhea themselves (Strina et al., 2005). The administered home-made salt-and-sugar solutions were subject to various worrying lapses. Moreover, diarrhea is considered an every-day event and children are taken to a medical facility only in threatening cases (Barros et al., 1991).

Findings for Khorezm indicate similar behavior patterns (see 4.5.4). About 60% of the respondents manage diarrhea of both adults and children by self-treatment, administering unspecified pharmaceuticals. Taking antibiotics accounted for another 12% of the responses for children and for 11% of the adults. Furasolidon and Levamycitin were the antibiotics most frequently taken against diarrhea. In 2003, it was possible to buy 10 tablets of those medicines in the *Dori-Bozor* for about 350 *Sum* (US$ 0.35), compared to 300 *Sum* for two sachets of ORS (Rehydron®), which are sufficient for the preparation of 1 L of oral re-hydration therapy (ORT) solution.

Globally, the proportion of diarrheal episodes treated with ORT rose from 15% to 40% between 1984 and 1993 (Victora et al., 2000). After a 7-year intervention conducted in the northern areas of Pakistan, all respondents had heard of ORT and 65% of the mothers used ORS packets (Halvorson, 2004). In Khorezm and Karakalpakstan, based on the Multiple Indicator Cluster Survey, 30% of the children with diarrhea received ORS (UNICEF, 2001).

In this study, 47% of the survey respondents had heard about Rehydron®. Only 12% of the respondents indicated applying ORT in case of childhood diarrhea.

However, this difference might be due to the way the question was asked. While in the Multiple Indicator Cluster Survey questionnaire, the question was explicitly on application of ORT; in this study, one question directly concerned Rehydron® knowledge and another open-ended question measures taken in case of childhood diarrhea.

Another fact probably influencing the different outcomes was that the Multiple Indicator Cluster Survey did not distinguish between Khorezm and Karakalpakstan. As

Karakalpakstan has been the subject of humanitarian aid projects, the knowledge on ORT is likely to be higher among the population in that area than in Khorezm.

In Khorezm, the vast majority – of those respondents who knew Rehydron® – thought it was a curative treatment against diarrhea. This fact was also found by Bentley (1988) in India, where disappointed mothers stopped using ORS. The population in Khorezm prefers self-treatment with pharmaceuticals or traditional methods, e.g., herbal remedies mostly applied as infusions. The self-medication with pharmaceuticals, especially antibiotics, is likely due to both reasons: lack of knowledge and high price of ORS (see 4.5.4). Since the mean number of episodes per year for the age group under two is 6.7 episodes and the mean duration of a diarrhea episode is 3.8 days, the needed number of ORS sachets (each for 1000 mL) per week for Khorezm amounts to approximately 60,000 sachets (US$ 4,000, wholesale price), supposing that 2 L per child under two would be administered.

Typical signs of dehydration (dry mouth and tongue, no tears when crying, sunken abdomen, eyes or cheeks, listlessness or irritability, skin that does not flatten when pinched and released) were never mentioned as a reason to seek medical advice in case of diarrhea. The need for medical consultation was assessed due to the duration of diarrhea or to stool appearance. Stool with mucus, blood or pus was the most important reason for health care seeking followed by the duration.

Breast-feeding is known to be a protective factor against infection and case fatality of early childhood diarrhea (Fuchs et al., 1996; Huttly et al., 1997; Victora et al., 1989). The optimal duration of exclusive breast-feeding is recommended to be 6 months (Kramer and Kakuma, 2002).

During the weaning period, infants are highly vulnerable to diarrheal diseases transmitted via contaminated food and liquids, and weaning education yielded an estimated reduction of 2 - 12% in diarrhea mortality (Ashworth and Feachem, 1985). According to the Multiple Indicator Cluster Survey (UNICEF, 2001), breast-feeding is widely practiced in Uzbekistan, but the majority of children receive additional liquids and food already at earliest ages. Thus, the exclusive breast-feeding rate is low, while the rate of continued breast-feeding is high.

The results of this study prove a similar trend, since all but one infant were breast-fed and received additional food and liquids. Although weaning started on average with the age of 6-months, some children received weaning foods and liquids very early. Till the end of the second year of life, 77% of infants were still partially breast-fed. Therefore, proper scheduling of weaning and safe preparation of weaning foods as well as of feeding utensils need to be addressed in health hygiene education programs in the region.

4.6.4 Additional aspects

Finally, two aspects of waterborne disease – recreational water use and waste water irrigation – which went beyond the scope of this study and were therefore not studied, are also related to water, sanitation and hygiene. Recreational use of surface waters by boys was regularly observed during the course of the study. As soon as the weather gets warm, boys spend their leisure time swimming and diving in heavily polluted canals and *aryks*. For that reason, one would expect a substantially higher diarrheal disease incidence in boys between 5 and 15 than in girls. However, boys in this age group suffer from only 0.1 episodes more than girls – with a longer duration of a single episode of 0.9 days – in summer (see Table 4.8).

The common practice of using untreated human excreta and fecally polluted surface water for irrigation of vegetables and fruits is likely to cause a high incidence of fecal-oral diseases. Worm eggs survive between one and two years in the environment, thus incidence of helminthic diseases is expected to be high.

5 GENERAL DISCUSSION

Globally, fecal-oral transmitted diseases due to water, sanitation and hygiene are a major cause of morbidity and mortality (WHO and UNICEF, 2000). Roughly 90% of this disease burden occurs in children under five years of age (Prüss et al., 2002) and 88% (1.5 million cases) of these diarrheal disease incidences is attributed to unsafe drinking water, sanitation and poor hygiene (Bartram et al., 2005). Therefore, progress in achieving Millennium Development Goal No. 7 is of paramount importance. Compared to results from the Joint Monitoring Program on Water Supply and Sanitation (WHO and UNICEF, 2004) access to safe drinking water supplies in Khorezm lags behind the national Uzbek average (89%). On the other hand, access to basic sanitation in Khorezm exceeds the national average (57%) (WHO and UNICEF, 2004).

An important monitoring problem is due to scale: exposure is on the household or individual level, but the respective information is usually available only on a local or regional administrative level (Prüss et al., 2002). Thus, large-scale data collection is disconnected from micro-scale health risks, and it is impossible to investigate the behavioral and socio-economic factors that influence exposure (Ezzati et al., 2005). Therfore, the WHO and UNICEF are conducting a pilot study to develop strategies for assessing drinking water quality on the household level (WHO and UNICEF, 2004). Since the unit of observation of the present study is the household, the study also contributes to an exposure assessment on a micro-level and unveils differences between the regional and household scale.

According to the definitions of the Joint Monitoring Program on Water Supply and Sanitation, 86% of the enrolled households in this study have access to improved drinking water sources. In the Khorezm region, dug wells (14%) are more or less protected by a brick or cement lining, but are without a cover and, therefore, in the present study are regarded as unimproved water supply. In Urgench city – the most urbanized area of Khorezm *tuman* – 74% of the population, 11% less than the urban national average, has access to a household water connection. In the rural *tumani* of Khorezm *viloyat*, the population often relies almost completely on dug wells and tube wells, as only a small percentage of the population – those living in the *tuman* center – have access to a piped household water supply.

About 20% of the households subjected to unimproved water supply use surface water sources for domestic purposes such as laundry (10%), cleaning (3%) and watering the yard (17%). As surface waters are contaminated by untreated sewerage discharge from private houses and other waste water, this can pose a threat to the exposed persons and contaminate objects which are meant to be cleaned. Moreover, the widely spread habit of storing drinking water in the household – resulting in a poor microbiological quality of the water – exposes people to unsafe water at the POU. Clear violations of the safety distance between well and latrine also contribute to the chemical and microbial contamination of drinking water sources.

According to data from the present study in Khorezm, about 96% of the population has access to improved sanitation, 41% more than stated for Uzbekistan in the Joint Monitoring Program on Water Supply and Sanitation report. Here, the same definition is used: all households having at least one simple pit latrine are regarded as having access to improved sanitation; only those with shared sanitation facilities (4%) are regarded to have access to unimproved sanitation.

However, what does ‘potentially improved sanitation’ mean in terms of fecal-oral pathogen load of the environment in Khorezm? Not being aware of fecal-oral disease transmission, people frequently apply untreated human excreta as fertilizer to agricultural fields and vegetable gardens. In addition, in 59% of the households, highly infectious children’s feces are not safely disposed of – in the domestic domain – and contaminate the surroundings. It is quite critical that a lot of potentially safely disposed human excreta are brought back to the domestic and public environment, posing a hazard to public and personal health. A further harmful practice is considered to be the households’ sullage disposal; the major part of the sullage (88%) is discharged untreated into the closer environment and surface waters.

The outcomes from this study reveal a high fecal-oral pathogen load in the environment despite a substantial coverage by a safe water supply and basic sanitation. This goes along very well with a recently estimated burden of disease from water, sanitation and hygiene at a global level by Prüss et al. (2002). Based on an assessment of the fecal-oral pathogen load in the environment, they used six exposure scenarios reflecting low to very high exposure. According to this assessment in Uzbekistan (WHO epidemiological sub region EUR-B1, low adult mortality, low child mortality), 87% of the population is exposed to high and 13% to very high fecal-oral pathogen loads.

In the same study, risk transition from high to low fecal pathogen load – by completing coverage with improved water supply and sanitation – as is partially taking place in Uzbekistan, was considered as the most difficult to prove. Hence, results from intervention studies and their contribution in cutting the incidence of diarrheal diseases have been the basis for estimating benefits. In intervention studies, the risk of diarrhea was decreased by promoting: improved water supply (16%), improved water quantity (20%), sanitation (36%) (Esrey et al., 1991), hygiene education (35%) (Huttly et al., 1997) and hand washing with soap (53%) (Luby et al., 2004). These results and results from the present study indicate that in Khorezm interventions dealing with sanitation and hygiene education should have priority. Especially promotion of hand washing is of major importance, as a meta-analysis of 38 interventions shows that hand washing resulted in a reduction in diarrheal disease incidence of 47% (Curtis and Cairncross, 2003a).

Prüss et al. (2002) also project a shift in the relative risk from a low to high pathogen-loaded environment of 1.54 due to improvements in personal hygiene and of 2.77 due to the combination of hygiene and water quality improvements at the POU (Prüss et al., 2002). Reverse associations between adequate excreta disposal and proper hygienic behavior have been proven. Unhygienic behavior was a risk factor for diarrheal disease (relative risk = 1.9, 95% CI = 1.5 - 2.5) (Strina et al., 2003). In a situation were the fecal contamination is high, diarrheal diseases are endemic and predominantly transmitted from person-to-person with or without multiplication in the environment. Aiming at the reduction in fecal-oral disease transmission in such conditions, interventions should focus on sanitation and hygiene rather than on water quality improvements by establishing primary barriers such as safe stool disposal and protection of water sources (Curtis et al., 2000).

The low quantity of drinking water used per capita per day in Khorezm has been proven by this and other studies (Kudat et al., 1995; Oldham et al., 1999). In concert with the results of the spot checks, which only rarely found hand wash facilities close to the latrine, and the common absence of soap at the hand wash facility, the very low water consumption suggests that a high percentage of the fecal-oral disease incidences is likely to be transmitted by the water-washed transmission route.

Regrettably, interventions in the sanitation sector based on conventional approaches including lecturing of hygiene practices and subsidized provision with sanitation have been ineffective (Cairncross, 2003a). People have to be motivated to accept and support an intervention, which is the basis for benefiting from it. The driving force can be: a desire, a need to be convinced of the usefulness or to have a personal benefit from an intervention. However, people with heavy financial constraints – 78% of the average monthly Uzbek income is spent on staple foods (Kudat et al., 1995) – mainly worry about how to save money or how to earn money wherever possible to cover living costs.

A well designed and safe nutrient recycling strategy (ecological sanitation) could lead to micro-cultural change in sanitation practices. As ecological sanitation could offer financial incentives, it is likely to facilitate implementation of such safe recycling strategies, which would impact on the micro- and macro-level by tackling aspects of water protection, agriculture and public health.

The application of composted human excreta as fertilizer in agriculture reduces the amount of industrial fertilizer needed. This implies that people buying less fertilizer save money or even benefit from additional earnings by selling fertilizer. Another positive effect could be achieved through more balanced nutrient flows on the regional, national and possibly also international level.

Abandoning the use of untreated human excreta as fertilizer in vegetable gardens and fields would interrupt the transmission of fecal-oral diseases in the domestic and public domains. Likewise, stopping the discharge of untreated or insufficient treated domestic waste water into the environment would improve microbiological surface and groundwater quality, thereby breaking the fecal-oral disease transmission path.

Sustainable approaches for marketing sanitation and hygiene are available (Cairncross, 2003b; Curtis and Cairncross, 2003b; Frias and Mukherjee, 2005). Besides, the gains in public health improvement in water supply, sanitation and hygiene also provide economic benefits (Hutton and Haller, 2004).

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The survey on diarrhea and risk factors in Khorezm revealed that sanitation-related behavior causes a fecal-oral pathogen loaded environment by open defecation of children in the premises, unsafe recycling of excreta from pit latrines and sullage disposal. Multiple linear regression analysis showed that two associated risk factors play a key role in diarrheal disease transmission on the inter-household level: the absence of anal cleansing material and visible contamination of stored drinking water.

Hence, domestic hygiene, sanitation and health-related behavior play a major role in fecal-oral disease transmission in Khorezm. This is emphasized by the high incidence of diarrheal disease currently occurring in children aged under two, who are cared for by family members at home. Therefore, it is concluded that fecal-oral disease transmission occurs predominantly in the domestic domain. Because most people have additional financial constraints, an intervention should set incentives to invest energy and money into hygiene and sanitation and not simply spread regulations and lectures. Therefore, only a participatory approach seems to be appropriate to meet those requirements.

In Khorezm, health-related behavior is often not founded on knowledge-based risk assessments and is move driven by habits or traditions. This results in self-management of diarrhea and hazardous self-medication with pharmaceuticals, especially for children.

Quantification of the extent of microbial contamination of the different water sources utilized for drinking water purposes was another major goal of this study. Regarding the drinking water quality for each source, specific problems could be identified. The presence of fecal coliforms and enterococci was found in all sources, but with a different magnitude, whereas deterioration during storage was demonstrated for all sources. The microbiological safety of the domestic water sources is therefore assessed as critical. Strategies to promote proper collection and household storage of drinking water must be encouraged, because stored water touched by hands and stored in unclean vessels poses a risk to consumers' health.

6.2 Recommendations

The recommendations mainly aim at establishing primary barriers in fecal-oral disease transmission:

1. Hygienically safe pit emptying techniques, nutrient recycling and sullage disposal in the private domain. Upgrading of sanitation facilities and hygiene education in the public domains (kindergartens, schools, universities).
2. Elimination of open defecation by children and safe disposal of children’s excreta.
3. Improvement of protection of water sources by keeping safety distances between latrines and wells, providing dug wells with covers and avoiding priming in hand pumps.
4. Conduction of a representative structured observation on hand washing behavior – to verify the results of this study – and subsequent promotion of proper hand washing after contact with fecal matter.
5. Health education on causes, prevention and proper management of diarrhea with regard to anal cleansing and strategies on safe drinking water storage.

Taking into account local drinking water taste problems, one recommendation concerning secondary barriers of fecal-oral disease transmission targets at the development of sustainable and affordable POU treatment of drinking water. Here, the local production of small-scale solar systems facilitating desalinisation and disinfection would be an optimal solution.

Based on the observations during the course of the study and the results, further research needs could be identified:

- Long-term ingestion of saline drinking water and its effect on human health.
- Incidence of methemoglobinemia in rural areas due to high nitrate contamination of decentralized drinking water sources (> 50 mg/L).
- Recreational water use and its impact on human health.
- Irrigation with sewage-contaminated surface water, helminthic diseases and child malnutrition.

7 GLOSSARY

Access to basic sanitation	Coverage with access to basic sanitation is expressed as the percentage of the population using improved sanitation.
Access to safe water supply	Coverage with access to safe water supply is expressed as the percentage of the population using improved drinking water sources.
Admission	The official acceptance into a health care service facility and the assignment of a bed to an individual requiring medical or health services on a time-limited basis.
Anemia	A pathological deficiency in the oxygen-carrying component of the blood, measured in unit volume concentrations of hemoglobin, red blood cell volume, or red blood cell number.
Aryk	Uzbek word for small irrigation ditch.
Burden of disease	The total significance of disease for society beyond the immediate cost of treatment. It is measured in years of life lost to ill health as the difference between total life expectancy and disability-adjusted life expectancy.
Calendar week	A period of seven consecutive days starting on Monday.
Cardiovascular diseases	Diseases of, relating to, or involving the heart and the blood vessels are cardiovascular diseases.
Consumption	To take in as food; eat or drink up.
Crude birth rate	The CBR measures the frequency of childbirth in a population. It is calculated as the number of live birth per 1,000 mid-year population.
Crude death rate	The CMR measures the frequency of death in a population. It is calculated as the number of live births per 1,000 mid-year population.
Cumulative incidence rate	The cumulative incidence rate is a measure for the risk of individuals in a population of contracting the disease during a specified period.

Dehydration	Diarrheal dehydration is a leading child killer in developing countries, largely because of inadequate sanitation. It claimed the lives of an estimated 2.2 million children under age 5 in 1995 alone. As many as 90% of these deaths could have been prevented with oral rehydration therapy (ORT).
Diarrhea	Diarrhea can be defined in absolute or relative terms based on either the frequency of bowel movements or the consistency (looseness) of stools.
Diarrhea episode	A diarrhea episode is a single diarrhea incident. A new episode is defined as an interval of a symptom-free time span (often 3 days) before the next diarrhea incident.
Disease burden	Size of a health problem in an area, measured by cost, mortality, morbidity, or other indicators. Knowledge of the burden of disease can help determine where investment in health should be targeted.
Domestic hygiene	All activities to keep the house and people's clothes and bedding clean. This comprises sweeping and washing floors, cleaning the toilet, washing clothes and bedding as well as washing dishes and cooking utensils after meals.
Dori-Bozor	Market/bazaar where pharmaceuticals are sold.
Dug well	A large diameter well dug by hand, usually old and often cased by concrete or hand-laid bricks. Such wells typically reach less than 50 feet in depth and are easily and frequently contaminated.
Dysentery	Bacillary dysentery or bloody diarrhea occurs due to infection with *Shigella* spp.
Ecological sanitation	Ecological sanitation is based on the concept of resource control by reuse of nutrients, water and energy. Nutrient cycles can be closed by sustainable use of human excreta in agriculture and aquaculture.
Effluent	Wastewater (treated or untreated) that flows out of a treatment plant, sewer, or industrial facility; generally refers to wastes discharged into surface waters.
Exposure	The condition of being subject to some detrimental effect or harmful condition.

Gross domestic product	The GDP is the most widely used concept of national income defined in the System of National Accounts. It represents the total final output of goods and services produced by an economy during a given period, regardless of the allocation to domestic and foreign claims and is calculated without making deductions for depreciation.
Groundwater	The supply of freshwater found beneath the earth's surface, usually in aquifers, which supplies wells and springs.
Health	A state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity.
Health care facility	A building or group of buildings under a common corporate structure that houses health care personnel and health care equipment to provide health care services (e.g., diagnostic, surgical, acute care, chronic care, dental care, physiotherapy) on an in-patient or out-patient basis to the public in general or to a designated group of persons or residents.
Health indicator	An indicator applicable to a health or health-related situation.
Health system	The people, institutions and resources, arranged together in accordance with established policies, to improve the health of the population they serve, while responding to people's legitimate expectations and protecting them against the cost of ill health through a variety of activities whose primary intent is to improve health. Health systems fulfil 3 main functions: health care delivery, fair treatment to all, and meeting non-health expectations of the population. These functions are performed in the pursuit of 3 goals: health, responsiveness and fair financing.
Heterotrophic	Refers to organisms which consume other life forms to acquire complex organic compounds of nitrogen and carbon for metabolism.
Ichketar	Simple Uzbek word for diarrhea.
Improved sanitation	Improved sanitation comprises connection to a public sewer, connection to a septic system, pour flush latrine, simple pit latrine and ventilated improved pit latrine.
Improved water supply	Improved drinking water sources comprise household connection, public stand pipe, borehole, protected dug well, protected spring, and rainwater collection.

Incidence	The number of new cases of disease during a period of time.
Indicator	Variable susceptible of direct measurement that is assumed to be associated with a state that cannot be measured directly. Indicators are sometimes standardized by national or international authorities.
Infant	Life span between birth and the first year of age.
Infant mortality rate	The IMR is a measure of the frequency of the death of infants between birth and the first year of age. It represents the annual number of death of infants under 1 year of age per 1,000 live births during the same period.
In-patient	A patient who is admitted to a hospital, clinic or other health care facility for treatment that requires at least one overnight stay.
Intervention	An activity or set of activities aimed at modifying a process, course of action or sequence of events, in order to change one or several of their characteristics such as performance or expected outcome.
Ladling	To draw water from a storage vessel by use of a ladle or dipper
Latrine	A site or a structure, normally located normally outside the house or building, destined to receive and store excreta and sometimes to process them (composting).
Leaching	To remove soluble or other constituents from the soil by the action of a percolating liquid.
Life expectancy at birth	A measure of the general level of mortality, this is the theoretical number of years a newborn will live if the age-specific mortality rates in the year of births are taken as constant.
Live birth	According to the standard definition of the WHO, this includes all births, with the exception of stillbirth, regardless of size, gestation age, or ‘viability’ of the newborn infant or her or his death soon after birth or before the required birth-registration date. The Soviet definition regards infants born with no breath, but with other signs of life (‘stillbirth’), infants born before the end of the 28th week of pregnancy, at a weight under 1,000 grams or a length under 35 cm and who die during the first seven days of life (‘miscarriages’) **not** as live birth.

Mahalla	Smallest administrative unit in Uzbekistan
Methemoglobinemia	A clinical condition in which more than 1% of the hemoglobin in the blood has been oxidized to the ferric (Fe^{3+}) state. The principle finding is cyanosis due to the oxidized hemoglobins inability to transport oxygen. Nitrites can cause this condition.
Morbidity rate	The morbidity rate measures the frequency of illness and is useful for the investigation of diseases with low case fatality.
Mortality rate	The number of deaths in a group of people usually expressed as deaths per thousand.
Most Probable Number	A method for estimating the number of viable bacteria in a specified volume using a tube dilution method.
Natural population growth	The difference between the number of births and the number of deaths during a given year divided by the mid year population. It excludes changes due to migration and may be positive or negative.
Neonatal death	The numbers of deaths in infants under 28 days of age in a year, per 1000 live births in that year.
Oblast	Russian administrative unit corresponding to state.
Oral re-hydration salt (ORS)	ORS are widely considered to represent the best method for combating the dehydration caused by diarrhea. They consist of a solution of salts and other substances such as glucose or molasses, which is administered orally.
Oral re-hydration therapy (ORT)	ORT is defined as an increased volume of fluids, either oral re-hydration salts (ORS) or other recommended home fluids, along with continued feeding addresses the dehydration promptly by replacing body fluids lost by diarrhea at the first sign of the disease.
Out-of-pocket payment	Fee paid by the consumer of health services directly to the provider at the time of delivery.
Out-patient	A patient admitted to a hospital, clinic or other health care facility for treatment that does not require an overnight stay.
Personal hygiene	Includes all activities to keep the body clean. Some of them are washing hands after contact with fecal matter, showering, washing hair, brushing teeth.

Piped water	Drinking water supply with treated water, which is delivered by a water distribution system.
Prevalence rate	The number of people in a particular area who currently have a disease and have not been cured of it.
Protected well	Since shallow wells take water from the highest water table, they are extremely sensitive to those activities that take place in the immediate vicinity of the well. Therefore wells should be protected from contamination by appropriate sealing, coverage for open wells, safety distances to surface water and latrines as well as hygienically safe abstraction of water.
Pump-priming	Introducing water into a pump to improve the seal and start the water flowing.
Purchasing power parity (ppp US$)	The PPP is a standardized measure of the purchasing power of a countries currency, based on a comparison of the number of units of that currency required to purchase the same representative basket of goods and services in a reference country and its currency (usually US dollars).
Rayon	Russian administrative unit corresponding to district.
Relative risk (RR)	RR = 1 in case of risk equality for exposed and non-exposed persons.
Risk factor	Factor is a factor associated with an increase in the chances of getting a disease; it may be a cause or simply a risk marker. Factors associated with decreased risk are known as protective.
Safe drinking water supply	The water does not contain biological or chemical agents at concentration levels directly detrimental to health. 'Safe water' includes treated surface waters and untreated but uncontaminated water such as that from protected boreholes, springs, and sanitary wells. Untreated surface waters, such as streams and lakes, should be considered safe only if the water quality is regularly monitored and considered acceptable by public health officials.
Salinity	The concentration of dissolved salts in water.
Salmonella spp.	Various rod-shaped bacteria of the genus Salmonella, many of which are pathogenic, causing food poisoning, typhoid, and paratyphoid fever in humans and other infectious diseases in domestic animals.

Shigellosis	Dysentery caused by any of various species of shigellae, occurring most frequently in areas where poor sanitation and malnutrition are prevalent and commonly affecting children and infants.
Simple pit latrine	A simple wooden or concrete slab installed over a pit of 2 m or more in depth. This support should stand on a sufficiently waterproof edge of the pit to avoid surface water (runoff and grey water) entering and destroying the facility. The pit should be lined in case of unstable soil where there is a risk of walls collapsing.
Stakeholder	Any party to a transaction which has particular interests in its outcome.
Stillbirth rate	According to the Soviet definition infants born with no breath, but with other signs of life are registered as stillbirth. It is calculated as the number of stillbirths per 1,000 live births.
Sullage	Domestic waste water without human excreta.
Surface water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.).
Surveillance	Surveillance includes the collection of data and the review, analysis and dissemination of findings on incidence (new cases), prevalence, morbidity, survival and mortality. Surveillance also serves to collect information on the knowledge, attitudes and behaviors of the public with respect to practices that prevent cancer, facilitate screening, extend survival and improve quality of life.
Total fertility rate	An overall measure of fertility, this represents the theoretical number of births to a woman during her childbearing years taken the given year's age-specific birth rates as a constant. It is calculated as the sum of the age-specific birth rates for all women of childbearing age.
Total microbial count	Enumeration and differentiation of heterofermentative lactobacilli and lactic streptococci.
Tube well	Device installed into a well to abstract groundwater from an aquifer. A well is first drilled into the ground and then a pipe assembly is lowered, which consists of an intake section and a discharge section. The intake section consists of a slotted part, the well screen, and a blind pipe. The discharge section consists of housing pipe, pump and discharge mouth or sprout.

Tuman	Uzbek administrative unit corresponding to state.
Turbidity	A measure of water cloudiness caused by suspended solids.
Under-5 mortality (U5MR)	The U5MR measures the probability of dying between birth and age 5. It represents the annual number of deaths of children under age 5 per 1,000 live births.
Unimproved sanitation	Unimproved sanitation comprises a public or shared latrine, open pit latrine and bucket latrine.
Unimproved water supply	Unimproved drinking water sources comprise unprotected well, unprotected spring, rivers or ponds, vendor-provided water, bottled water and tanker truck water.
Unprotected well	The term unprotected well comprises old wells, improperly installed wells, and abandoned or active water wells that impact groundwater. Runoff can carry contaminated water into low-rising, unprotected well openings.
Viloyat	Uzbek administrative unit corresponding to district.
Viral hepatitis	Any of various forms of hepatitis caused by a virus. Viral hepatitis is an inflammation of the liver caused by the hepatitis A, B, C, E virus. Symptoms include nausea, muscle ache and jaundice. Hepatitis A and E are transmitted via the fecal-oral transmission route. Hepatitis B and C are transmitted via body fluids.
Water distribution system	The system of pipes supplying water to communities and industries.
Water quality	Physical, chemical, biological and organoleptic (taste-related) properties of water.
Waterborne disease	Disease that arises from ingestion of microbial or chemical contaminated water and is transmitted when the water is used for drinking or cooking (for example, cholera or typhoid, methemoglobinemia, arsenosis).

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9 APPENDICES

Appendix 9.1 Diarrhea diary

DD1 20th week

Who delivered the form: ____________ DD2 Code: ____________ DD4 Date: ____________

Who picked up the form: ____________ DD3 Code ____________ DD5 Date: ____________

DD6 MARK THE RESPONDENT	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Name							

IN CASE THE TABLE IS NOT FILLED IN, ASK WHETHER IT WAS DUE TO PROBLEMS OR DID REALLY NO DIARRHEA OCCUR ?

I → diarrhea
V → vomiting
N → nausea

IN CASE THE TABLE IS NOT FILLED IN DUE TO SOME PROBLEMS ASK FOR REASONS AND EXPLAIN WITH PATIENCE AND AS OFTEN AS NEEDED THE APPROPRIATE SOLUTION FOR THIS PROBLEM !!!

ASK ALSO FOR DIARRHEA IN THE RESPECTIVE WEEK AND FILL THE FORM YOURSELF

DD7 Which uncooked food did you prepare for the family meals yesterday?

tomatoes	1	melons	8
cucumbers	2	cherries	9
salad	3	green apricots	10
herbs	4	strawberries	11
carrots	5	chopped meat	12
reddish	6	other/specify	13 ____________
onion	7		

DD 8 Did familiy members eat pre-prepared food yesterday?

yes	1
no	2

DD9 Which members of the family suffered from the following symptoms during the previous week and has anybody received a medical consultation ?
MAKE A CROSS IN TABLE FOR EVERY FAMILY MEMBER IN WHOM SYMPTOMS OCCURRED, MORE THAN ONE ANSWER POSSIBLE

IN CASE NO DIARRHEA OCCURRED IN THE PREVIOUS PAGE DO NOT ASK FOR DIARRHEA ! MARK THE RESPONDENT

	DD9_1	DD9_2	DD9_3	DD9_4	DD9_5	DD9_6	DD9_7	DD9_8
Name	fever/days	cough	pain/specify	diarrhoea with blood	diarrhoea with mucus	pale stool	dark urine	med. consultation

← PUT IN CODE
0 no
1 doctor
2 felcher
3 nurse
4 polyclinic
5 hospital
6 emergency service
7 private (med. ed.)
8 tabib
9 other

DD10 How many drinking water sources did you use in the previous week ? FILL IN NUMBER MENTIONED ________

DD11 How was your drinking water in the previous week ? MORE THAN ONE ANSWER POSSIBLE

nothing special	1	less salty than usual	5	bad smell	9
not enough water	2	other colour than usual	6	other/specify	10 ______________
discontinuous water supply	3	other taste than usual	7		
more salty than usually	4	high turbidity	8		

IF THE ANSWER IS "DISCONTINUOUS WATER SUPPLY" ASK, PLEASE

DD12 How many hours per day you had access to the centralised drinking water in average in the previous week?

FILL IN NUMBER MENTIONED ______ in the morning ________________ in the afternoon/evening

PLEASE, NOTE EVERY ADDITIONAL COMMENT ON DRINKING WATER

Appendix 9.2 Spot check form 1

DWS_1 Interviewer (name):		**DWS_2 Interviewer code:**	
DWS_3 Date of interview:		**DWS_4 Duration of interview:**	**from till**
DWS_5 District:		**DWS_6 District code:**	
DWS_7 Name of citizen's micro district:		**DWS_8 Code of citizen's micro district:**	
DWS_9 Head of the household (name, surname):		**DWS_10 Household code:**	

DWS_11 Date of visit and acceptance of information:	**DWS_12 Person, accepting the information:**

DWS_13 Date of entering the information:	**DWS_14 Data operator:**

DWS_15 Is the drinking water stored in this household? yes 1 no 2 sometimes 3

IF THE ANSWER IS «NO», QUESTIONS ON STORAGE OF DRINKING CAN BE SKIPPED

IF THE ANSWER IS «YES», ASK PERMISSION TO HAVE A LOOK AT THE PLACE WHERE WATER IS STORED AND ASK THE FOLLOWING QUESTIONS

DWS_16

Where is the drinking water stored?

inside the house	1
outside the house	2

DWS_17

Where exactly is the drinking water stored?

kitchen	1	
bathroom	2	
yard	3	
other/specify	4	________

DWS 18 Type of storage vessel ?		DWS 19 Cleanliness of vessel?				DWS 20 Is there any sediment on the bottom of the vessel?		DWS 21 How does the sediment look like?		DWS22 Is the vessel covered or not covered?		DWS 23 Is there anything else visible in water?			
		Very clean	Clean	Dirty	Very dirty	Yes	No	Thick layer	Thin layer	Yes	No	Plant pieces	Little insects	Nothing	Other/ specify
Bucket	1														
Pan	2														
Barrel	3														
Bottle	4														
Tank	5														
Basin	6														
Cistern	7														
Flask	8														
Jar	9														
Other/specify	10														

TOILET CHECK

			yes	no
T_1 Is there any toilet paper?			1	2
T_2 Is there any other cleansing material?			1	2
T_3 Is the used toilet paper kept in closed bin?			1	2
T_4 Is used toilet paper kept in open bin (without a lid)?			1	2

T_5 How full was the bin?	empty	1	half full	3
	less then half full	2	full	4
T_6 How clean was the toilet?	very clean	1	dirty	3
	clean	2	very dirty	4

Notes:

Appendix 9.3 Spot check form 2

DWS_1 Interviewer (name):		**DWS_2 Interviewer code:**	
DWS_3 Date of interview:		**DWS_4 Duration of interview:**	**from till**
DWS_5 District:		**DWS_6 District code:**	
DWS_7 Name of citizen's micro district:		**DWS_8 Code of citizen's micro district:**	
DWS_9 Head of the household (name, surname):		**DWS_10 Household code:**	

DWS_11 Date of visit and acceptance of information:	**DWS_12 Person, accepting the information:**

DWS_13 Date of entering the information:	**DWS_14 Data operator:**

DWS_15 Is the drinking water stored in this household? yes 1 no 2 sometimes 3

IF THE ANSWER IS «NO», QUESTIONS ON STORAGE OF DRINKING CAN BE SKIPPED

IF THE ANSWER IS «YES», ASK PERMISSION TO HAVE A LOOK AT THE PLACE WHERE WATER IS STORED AND ASK THE FOLLOWING QUESTIONS

DWS_16

Where is the drinking water stored?

	inside the house	1
	outside the house	2

DWS_17

Where exactly is the drinking water stored?

	kitchen	1
	bathroom	2
	yard	3
	other/specify	4 ____________

DWS 18 Type of storage vessel ?		DWS 19 Cleanliness of vessel?				DWS 20 Is there any sediment on the bottom of the vessel?		DWS 21 How does the sediment look like?		DWS22 Is the vessel covered or not covered?		DWS 23 Is there anything else visible in water?			
		Very clean	Clean	Dirty	Very dirty	Yes	No	Thick layer	Thin layer	Yes	No	Plant pieces	Little insects	Nothing	Other/ specify
Bucket	1														
Pan	2														
Barrel	3														
Bottle	4														
Tank	5														
Basin	6														
Cistern	7														
Flask	8														
Jar	9														
Other/specify	10														

ASK PERMISSION TO SEE THE TOILET AND THEN BASED ON THIS START THE DISCUSSION ABOUT HYGIENE.

THIS QUESTIONNAIRE SHOULD BE HELPFUL FOR YOU DURING THE DISCUSSION.
IT IS NOT NECESSARY TO ASK QUESTIONS LITERALLY OR IN THE GIVEN ORDER. PLEASE FILL IN THE QUESTIONNAIRE IMMEDIATELY AFTER LEAVING THE HOUSEHOLD.
PLEASE PAY ATTENTION TO THE AVAILABILITY OF TOILET PAPER OR OTHER CLEANING MATERIAL, WHERE IT IS KEPT AND OTHER GENERAL DETAILS RELATED TO TOILET CONDITIONS

VERY IMPORTANT: PLEASE, REMEMBER THESE FACTS!

		YES	NO
T_15	Is it a pit latrine (dug toilet)?	1	2
T_16	Does the latrine have concrete slabs?	1	2
T_17	Is it a flush toilet?	1	2
T_18	Is there special toilet paper available?	1	2
T_19	Is there any other paper available?	1	2
T_20	Is used toilet paper kept in closed bins?	1	2
T_21	Is used toilet paper kept in open bins (without a lid)?	1	2
T_22	Are these bins crammed full?	1	2

T_23 How clean is the place of the latrine or flush toilet?

very clean 1 clean 2 dirty 3 very dirty 4

		Yes	No
T_24	Are there any hand washing facilities close to the toilet?	1	2
T_25	Is there water in the device for washing hands?	1	2
T_26	Is it provided with soap?	1	2
T_27	Is it provided with towel?	1	2

YOU CAN START A DISCUSSION BY POSING THE FOLLOWING QUESTIONS:

T_28 Does the pit latrine have a ventilation? yes 1 no 2 don't know 3

IF THE USED TOILET PAPER IS KEPT IN BINS PLEASE ASK

T_29 How do you dispose of used toilet paper?

throw into garbage 1 burn 2 other/clarify 3 ________________

IF THERE ARE CHILDREN IN THIS HOUSE ASK PARENTS HOW THEY CLEAN THEM AFTER DEFECATION

T_30 What do you use for cleaning your child after using the toilet (= defecation)?
SEVERAL ANSWERS POSSIBLE

don't clean	1	toilet paper	4	cotton	7
with soil or ash	2	other paper or newspaper	5	other/clarify	8 ____________
cloth	3	water and soap	6		

T_31 Till what age could your children not use the toilet?

PLEASE WRITE THE EXACT AGE _______ age

T_32 If you have children who cannot use the toilet at the moment, where can they easily defecate?

yard 1 street 2 other/clarify 3 ____________________

T_33 How do you dispose of your child's faeces?

nothing	1	burn	4
throw them into the toilet	2	throw into the garden	5
cover with soil	3	other/clarify	6 ____________________

T_34 Do you wash your hands after using the toilet?

yes	1
no	2
sometimes	3

IF THERE IS A FLUSH TOILET, WHICH IS CONNECTED TO THE CENTRALIZED SEWERAGE SYSTEM, DO NOT ASK THE FOLLOWING QUESTIONS

T_35 How often is the latrine emptied?

once a year	1
twice a year	2
every two years	3
period of less than two years	4
other/clarify	5 ____________________

T_36 How is the latrine emptied?

by public service	1
by private service	2
dig out by family members	3
taken by cars	4
other/clarify	5 ____________________

T_37 How do you dispose your human excreta?

take to agricultural lands	1
dig under fruit trees and vineyards	2
use for vegetables in the garden	3
other/clarify	4 ____________________

Appendix 9.4 Socio-hygienic mapping check form

Q1 Interviewer (name):	______________	**Q2 Interviewer code:**	______________
Q3 Date of interview:	______________	**Q4 Time of interview:**	from till
Q5 District:	______________	**Q6 District code:**	______________
Q7 Name of citizens council:	______________	**Q8 Code of citizens council:**	______________
Q9 Household head (name):	______________	**Q10 Household code:**	______________

Check your social hygienic map for the following points, please!

Did you indicate how many family members each family has?

Did you indicate for all sanitation facilities which families use them?

latrine/toilet
hand wash facility
bathroom

Did you indicate the following facts for the well or hand pump?

depth _____
which families use them
distance between well or hand pump and latrine/toilet
which water do you use in order to run the hand pump _____
how long does the well/ hand pump exist _____

Did you indicate which families have a common budget?

Did you indicate which families share their meals?

Did you indicate which families grow fruits and vegetables on a common field?

Appendix 9.5 Questionnaire for risk factor study on diarrheal diseases

Q1 Interviewer (name): ________	**Q2 Interviewer code:** ________
Q3 Date of interview: ________	**Q4 Duration of interview: from till**
Q5 District: ________	**Q6 District code:** ________
Q7 Name of micro district: ________	**Q8 Code of micro district:** ________
Q9 Household head (name): ________	**Q10 Household code:** ________

Q11 Date of information acceptance:	**Q12 Operator accepting information:**

Q13 Date of information entry:	**Q14 Data operator:**

SECTION 1: CHILDREN AND CHILD CARE

IF THERE ARE NO CHILDREN UNDER THE AGE OF 7 IN THIS HOUSEHOLD, START WITH SECTION 2

Q15 Who in your house usually takes care of children under the age of 7?
IN CASE TWO OR MORE PERSONS DO, MARK THE MAIN CARETAKER

children's mother	1	children's father	5
children's grandmother	2	babysitter	6
other members of this household	3	friends or neighbors	7
other relatives	4	other/specify	8 ________

Q16 How many times per day do you feed your children?
PLEASE, WRITE AN EXACT NUMBER ________

Q17 LIST THE CHILDREN WHO GO TO THE KINDERGARTEN

name	**code**	**sex**	days per week	days per month
		M F		
		M F		
		M F		

Q18 Is there a breast-feeding child in your household at the moment?

IF NO, GO TO SECTION 2 OTHERWISE ASK FOR THE FOLOWING:

name	**age in months**	**sex**		**additional food to the maternal milk**		**any fluid other than maternal milk**	
		M	F	yes	no	yes	no
		M	F	yes	no	yes	no
		M	F	yes	no	yes	no

Q19 WRITE DOWN THE «NAME» OF THE CHILD, CODE FOR ADDITIONAL FOOD OR FLUID HE OR SHE RECEIVES AND AT WHICH AGE COMPLEMENTARY FEEDING STARTED ?

name	WRITE CODE / SEVERAL CODES POSSIBLE	**With how many months did you start giving it?**

FOOD CODE		FLUID CODE	
porridge	1	water	12
dairy products/yogurt, curds	2	boiled water	13
fresh fruits	3	black or green tea	14
mashed vegetables	4	cow milk	15
soup	5	juice	16
cookies, bread	6	rice water	17
eggs	7	“Malish” or “Nestle” as complementary food	18
honey	8	other fluids/specify	19
lamb fat	9		
daily food	10		
other food/specify	11		

SCETION 2: HEALTH AND ILL HEALTH

Q21 Have any of your family members suffered from infectious hepatitis. (hepatitis A) in the last 5 years or at present?

SEVERAL ANSWERS POSSIBLE

yes	1
no	2
yes, hepatitis, but we don't know the type	3

Write the names of those who were sick ______________________

Q22 What do you think is the reason for diarrhea?

SEVERAL ANSWERS POSSIBLE

dirty hands	1	sunstroke	7
dirty food	2	carelessness about cleanness	8
spoiled food	3	insects, flies	9
chemicals in water	4	intestinal cold	10
microbes in water	5	maternal milk/ specify why	11 ____________
non-hygienic conditions	6	other/specify	12 ____________

Q23 Do you know what measures you can take in order to prevent diarrhea?

SEVERAL ANSWERS POSSIBLE

don't know	1	feed children with a spoon	9
wash hands after using the toilet	2	boil nipple nursers	10
wash hands before cooking	3	clean children properly after going to the toilet	11
wash hands before having a meal	4	bury faeces of ill persons suffering from diarrhea	12
cover the food	5	keep toilets clean	13
drink only boiled milk	6	wash fruits and vegetables before eating	14
drink only boiled water	7	eat fresh cooked meals	15
breast-feeding	8	other/specify	16

____

____

____

Q24 How do you treat diarrhea cases of adults and children?

SEVERAL ANSWERS POSSIBLE

	adults	children
stop feeding	1	14
stop giving fluids	2	15
give boiled water	3	16
rehydration with salts / Rehydron®	4	17
give antibiotics	5	18
give medicines to stop diarrhea	6	19
give black tea with sugar	7	20
give rice water	8	21
give pomegranate tea	9	22
with the help of djida fruit	10	23
go to the hospital	11	24
old or traditional method/specify	12	25
other/specify	13	26

Q25 In which cases of diarrhea you seek health care at a medical facility?

SEVERAL ANSWERS POSSIBLE

	children	adults
if diarrhea lasts	more than …days	more than …days
if temperature lasts	more than …days	more than …days
in case of stools with blood or mucus	1	1
sunken eyes	2	2
hoarse voice	3	3
other/specify	4	4

Q26 When did you go to a medical facility the last time?

PLEASE WRITE AN EXACT MENTIONED NUMBER (ONLY ONE ANSWER IS POSSIBLE)

…… days ago …… months ago ……years ago

Q27 For what did you go to a medical facility the last time?

PLEASE WRITE DOWN THE MENTIONED REASON

Q28 Do you always go to a medical facility when you feel that you need medical advice because of some kind of illness?

yes, always	1
no, I don't	2
sometimes	3

Q29 If you don't like going or taking your child to a medical facility what is the reason for it?

SEVERAL ANSWERS POSSIBLE

no reason	1	
very expensive	2	
difficult to get to	3	
great distance	4	
have to wait too long	5	
other/specify	6	____________________

Q30 What do you know about Rehydron®?

SEVERAL ANSWERS POSSIBLE

nothing	1	
medicine against diarrhea	2	
solution containing minerals	3	
it is prepared with boiled water	4	
other/specify	5	________________________

SECTION 3: DRINKING WATER

3.1 DRINKING WATER SUPPLY

Q31 Which drinking water sources do you mainly use in winter and summer?

SEVERAL ANSWERS POSSIBLE

	winter	summer
water pipe inside the house or yard	1	1
water pipe outside the house or yard	2	2
well inside the house or yard	3	3
well outside the house or yard	4	4
hand pump inside the house or yard	5	5
hand pump outside the house or yard	6	6
river, lake, pond etc.	7	7
“aryk”	8	8
channel	9	9
delivered water	10	10
water in bottles or plastic bottles that are in sale	11	11
other/specify	12	12
	___________________	___________________

Q32 Is the quality of drinking water always the same or are there any differences?

SEVERAL ANSWERS POSSIBLE

yes, always the same	1	GO TO QUESTION Q34
no, there is no difference in water quality	2	

Q33 If there is a difference in water quality, what are its distinguishing features in winter and summer?

SEVERAL ANSWERS POSSIBLE

	winter		summer	
	tap	well	tap	well
suspended solids (turbidity)	1	8	15	22
salinity	2	9	16	23
benzine smell	3	10	17	24
presence of chemicals	4	11	18	25
visible contamination	5	12	19	26
animals (frogs, tadpoles and fishes)	6	13	20	27
other/specify	7	14	21	28

IF THERE IS NO WATER PIPE IN THE HOUSE OR IF THERE IS, BUT BECAUSE OF NO WATER IN IT, OTHER WATER SOURCES ARE USED, ASK QUESTIONS Q34-Q38

Q34 Who usually collects the drinking water for your household?

sex		age
M	F	________
M	F	________
M	F	________

Q35 How many times per day is water brought or collected?

WRITE AN EXACT NUMBER ______

Q36 How much water is brought when going once?

WRITE AN EXACT NUMBER ______ litre

Q37 What is the distance between you house and the drinking water source? ______ meters

WRITE AN EXACT NUMBER ______ kilometers

Q38 How is drinking water transported to your house?

SEVERAL ANSWERS POSSIBLE

	summer		winter	
carried by hand	1		1	
by car	2		2	
by cart	3		3	
other/specify	4	____________	4	____________

3.2 HOUSEHOLD DRINKING WATER STORAGE

Q39 What kind of vessels do you usually use for water transport?
SEVERAL ANSWERS POSSIBLE

buckets	1	barrels	3	
flasks	2	other/specify	4	________________

Q40 What kind of vessels/reservoirs do you usually use for storing water?

SEVERAL ANSWERS POSSIBLE

buckets	1	jugs	6	
basins	2	metal cisterns	7	
barrels	3	flasks	8	
bottles	4	other/specify	9	____________
tanks	5			

Q41 Do you clean your vessels/reservoirs before filling them with water?

yes, we do	1	
no, we don't	2	GO TO QUESTION Q42

Q42 How do you clean these vessels/reservoirs?

SEVERAL ANSWERS POSSIBLE

rinse the containers and pour the water out	1	use disinfectant	5
rinse with tap water	2	don't know	6
wash with soap	3	other/specify	7
use washing powder and other synthetic washing detergents	4	______________________	

3.3 HOUSEHOLD DRINKING WATER TREATMENT

Q43 What do you with water before using it for drinking purposes?

If you undertake some activities, are there any differences between these activities done in summer and winter months?

SEVERAL ANSWERS POSSIBLE

	summer		**winter**	
nothing GO TO QUESTION Q45	0		0	
settle water	1		1	
boil	2		2	
filter	3		3	
disinfect with chemicals	4		4	
other/specify	5	________________	5	__________

WHEN DRINKING WATER IS TREATED, PLEASE ASK THE FOLLOWING QESTIONS

Q44 Do you always do these activities?

ONLY ONE ANSWER IS POSSIBLE

yes, always	1
I usually do	2
only sometimes	3

3.4 DRINKING WATER CONSUMPTION

PLEASE ASK THIS QUESTION IN HOUSEHOLD WHERE WATER PIPE IS AVAILABLE

Q45 How is the water availability in winter and summer time?

	winter	summer
available from time to time	1	1
never available	2	2
available most of the time	3	3
available sometimes	4	4

Q46 Do you know how much drinking water your family consumes per day?

yes, I do	1	PLEASE WRITE THE EXACT NUMBER	________ litre
no, I don't	2		

Q47 If you were to evaluate the quality of your drinking water source, to what features would you pay great attention?

SEVERAL ANSWERS POSSIBLE

	tap water		well water	
cleanness	1		8	
color	2		9	
turbidity	3		10	
salinity	4		11	
smell	5		12	
don't know	6		13	
other/specify	7	____________	14	______________

Q48 How would you evaluate the quality of water you use for drinking purposes?

ONLY ONE ANSWER IS POSSIBLE

very good	1
good	2
not so good	3
bad	4
very bad	5

Q49 Do your family members accidentally drink unboiled water ?

yes	1	GO TO QUESTION 51
no, never	2	
don't know	3	GO TO QUESTION 51
sometimes	4	

Q50 Do your family members drink unboiled water in …?

	yes	no	don't know
in the school	1	2	3
in the kindergarten	1	2	3
at work	1	2	3
during field work	1	2	3
on the street	1	2	3
other/specify	1	2	3

Q51 Which type of water sources do you use for below-mentioned purposes?

MARK "X" FOR USED WATER SOURCE

Type of water sources	Purpose					
	drinking and cooking	**baths**	**laundry**	**cleaning rooms**	**watering the yard**	**irrigation of gardens**
water pipe inside the house or yard						
water pipe outside the house or yard						
well inside the house						
well outside the house or yard						
hand pump inside the house or yard						
hand pump outside the house						
river, lake, pond						
"aryk"						
channel						
delivered water						
water in bottles and plastic bottles						
other/specify						

SECTION 4: DOMESTIC HYGIENE

Q52 What kind of device do you use for washing hands?

SEVERAL ANSWERS POSSIBLE

tap (in the kitchen and the bathroom)	1
special device for washing hands (wash-stand)	2
“kumgon”	3
other /specify	4 ____________________

	yes	no	sometimes
Q53 Are your hand washing devices provided with soap?	1	2	3
Q54 Are your hand washing devices provided with water?	1	2	3
Q55 Do you always wash your hands before cooking?	1	2	3

Q56 How many times per day do your children wash their hands?

WRITE AN EXACT NUMBER ____________________

Q57 How does your family dispose of garbage?

SEVERAL ANSWERS POSSIBLE

by public service	1	by burning	4
by private service (fee)	2	throw at any place	5
special garbage collected place	3	other/specify	6

____

Q58 How does your household dispose of waste water?

SEVERAL ANSWERS POSSIBLE

connection to the public sewerage system	1
untreated discharge by self-constructed pipe	2
private service	3
pour into river or channel	4
pour into “aryk”	5
pour into yard or road	6
pour onto the tree or plant growing area	7
other/specify	8 ____________

SECTION 5: FOOD HYGIENE

Q59 Where do you usually clean and prepare vegetables for cooking?

on kitchen table	1
on kitchen floor	2
in kitchen in special bowl	3
in yard	4
other/specify	5 ____________________

Q60 Do you wash the following products before eating?

	yes	no	sometimes
vegetables	1	2	3
fruits	1	2	3
herbs/ salad leaves	1	2	3
strawberry	1	2	3
mulberry	1	2	3

Q61 How often do you prepare food in advance and eat it later on?
SEVERAL ANSWERS POSSIBLE

daily	1	seldom	3
often	2	never	4

Q62 How and where do you store cooked leftovers?
SEVERAL ANSWERS POSSIBLE

covered	1	kitchen	4
not covered	2	other/specify	5
refrigerator	3	____________________	

Q63 For how long do you usually store left-over of cooked meals?

less than 12 hours	1
between 12 - 24 hours	2
more than 24 hours	3

Q64 Did anybody except the respondent participate during the interview?

yes	1	no	2

PLEASE, SPECIFY RELATIONSHIP BETWEEN RESPONDENT AND THE OTHER PERSON BEING PRESENT

member of this household	1
other relative	2
friend	3
neighbour	4
other/clarify	5

Appendix 9.6 Drinking water sampling protocol

Drinking water sampling protocol

ЗЕФ Ичимлик сувидан келиб чикадиган касалликни текшириш учун сув намуналарининг варакаси

sampling point no.: ________ / намуна олинаетган жойнинг номери:

sampler: ________ / дегустатор:

sampling under sterile conditions: ☐ / намуна стерил холатда олинди:

date: ________ / сана:

time: ________ / вакт:

sampling under user conditions: ☐ / намуна одатдаги холатда олинди:

weather: ________ / об-хаво:

air temp. ________ °C / хаво харорати:

☐ rain within 24 hours before sampling / намуна олнгунча 24 соат давомида еггам емгир

☐ rain while sampling / намуна олинаетган пайтидаги емгир

type of sampling point: / намунаолинаетган жойнинг тури:

1	water tap inside the house/yard уй/ ховли ичидаги водопровод	6	hand pump outside house/yard уй/ ховли ташкарисидаги босма крант
2	water tap outside the house/yard уй/ ховли ташкарисидаги водопровод	7	river, lake, pond, stream даре,кул, ховуз, анхор.
3	well inside house/yard уй/ ховли ичкарисидаги кудук	8	aryk арик
4	well outside house/yard уй/ ховли ташкарисидаги кудук	9	canal канал
5	hand pump inside house/yard уй/ховли ичкаридаги босма крант	10	water storage point сув саклаш жойи

bacteriological sample: ☐ / бактериологик намуна:

type of odor: ________ / хиднинг тури:

water temperature: ________ °C / сувнинг харорати:

DPD 1 free chlorine: ________ mg/L / эркин хлор: мг/л

intensity of odour: ________ / хиднинг жадаллиги:

DPD 3 total chlorine: ________ mg/L / жами хлор: мг/л

color: ________ / ранг

nitrate: ________ mg/L / нитрат: мг/л

turbidity: ________ / лойкалиги:

nitrite: ________ mg/L / нитрит: мг/л

hand pumps/ босма крант/
water used for priming (hand pump) / Босма крантни ишлатиш учун солинадиган сув ☐ yes / ха ☐ no / йук

________ L boiled water / л кайнатилган сув

________ L unboiled water / л кайнатилмаган сув

weather **об-хаво**	
sunny куешли	1
cloudy булутли	2
rainy емгирли	3
changeable узгарувчан	4

type of odour **хиднинг тури**	
no smell хид йук	0
soil тупрок	1
chlorine хлор	2
faecal нажас хиди	3

intensity of odour **хид жадаллиги**	
weak кучли эмас	1
medium уртача	2
strong кучли	3

colour **ранг**	
no colour рангсиз	0
brownish жигар ранг	1
yellowish саргиш	2

turbidity **лойкалиги**	
no йук	0
weak кучли эмас	1
medium уртача	2
strong кучли	3

Comments/ :
Изох/ :

Appendix 9.7 Drinking water sampling points

SP	HH_ID	SP type	Location	Tuman	Mahalla
1	40109	tube well	inside yard or garden	Kushkupyr	Gozovot
2	40115	tube well	inside yard or garden	Kushkupyr	Gozovot
3	40206	tube well	inside yard or garden	Kushkupyr	Khosiyon
4	40207	dug well	on street	Kushkupyr	Khosiyon
5	40402	piped water	inside yard or garden	Kushkupyr	city
6	40405	tube well	inside yard or garden	Kushkupyr	city
7	40312	dug well	on street	Kushkupyr	Khonobod
8	40305	dug well	on street	Kushkupyr	Khonobod
9	30313	tube well	inside yard or garden	Khiva	Okyop
10	30314	drinking water storage	inside house	Khiva	Okyop
11	30315	drinking water storage	inside house	Khiva	Okyop
12	30316	tube well	inside yard or garden	Khiva	Okyop
13	30317	drinking water storage	inside house	Khiva	Okyop
14	30318	drinking water storage	inside house	Khiva	Okyop
15	30319	dug well	on street	Khiva	Okyop
16	30320	drinking water storage	inside house	Khiva	Okyop
17	30321	drinking water storage	inside house	Khiva	Okyop
18	30501	piped water	inside house	Khiva	mobod
19	30404	tube well	inside yard or garden	Khiva	Kumyaska
20	30404	piped water	inside house	Khiva	Kumyaska
21	30603	piped water	inside house	Khiva	Kaptarkhona
22	30307	dug well	on street	Khiva	Okyop
23	30308	tube well	inside yard or garden	Khiva	Okyop
24	30108	tube well	on street	Khiva	Chinobod
25	30108	dug well	on street	Khiva	Chinobod
26	30204	tube well	inside yard or garden	Khiva	Juryon
27	30204	dug well	on street	Khiva	Juryon
28	20219	piped water	on street	Urgench	Goybu
29	20201	tube well	inside house	Urgench	Goybu
30	20101	piped water	inside yard or garden	Urgench	Koromon
31	20104	tube well	inside yard or garden	Urgench	Koromon
32	10807	piped water	inside house	Urgench	Navruz
33	20307	piped water	inside house	Urgench	Korovul
34	20313	piped water	inside house	Urgench	Korovul
35	20313	tube well	inside yard or garden	Urgench	Korovul
36	10106	piped water	inside house	Urgench	Mustaqillik
37	10303	piped water	inside house	Urgench	Al Khorazmiy
38	11001	piped water	inside house	Urgench	Gulchilar
39	10504	piped water	on street	Urgench	Mashal
40	10904	piped water	inside house	Urgench	Dustlik
41	40402	drinking water storage	inside house	Kushkupyr	city
42	30501	piped water	on street	Khiva	mobod
43	30603	drinking water storage	inside house	Khiva	Kaptarkhona
44	10807	drinking water storage	inside house	Urgench	Navruz
45	30404	piped water	inside yard or garden	Khiva	Kumyaska
46	20210	piped water	inside yard or garden	Urgench	Goybu
47	11001	drinking water storage	inside house	Urgench	Gulchilar
48	30404	drinking water storage	inside house	Khiva	Kumyaska
49	20210	piped water	inside yard or garden	Urgench	Goybu
50	10101	piped water	inside house	Urgench	Mustaqillik
51	10101	self invented filter	inside house	Urgench	Mustaqillik

Appendix 9.8 Administrative distribution of analyzed households (171)

Tuman	*Mahalla*	Type	No. of HH	No. of individuals
Khiva	Binokor	urban	6	25
Khiva	Chinobod	rural	11	99
Khiva	Juryon	rural	14	93
Khiva	Kaptarkhona	urban	4	29
Khiva	Kumyaska	urban	5	33
Khiva	Okyop	rural	11	72
Kushkupyr	Gozovot	rural	16	122
Kushkupyr	Khonobod	rural	11	92
Kushkupyr	Khosiyon	rural	8	52
Kushkupyr	Kushkupyr city	urban	5	38
Urgench	Al Khorazmiy	urban	4	26
Urgench	Dustlik	urban	5	21
Urgench	E.Rahim	urban	3	20
Urgench	Goybu	rural	21	145
Urgench	Gulchilar	urban	7	28
Urgench	Koromon	rural	10	63
Urgench	Korovul	urban	9	58
Urgench	Mashal	urban	5	32
Urgench	Mustaqillik	urban	2	13
Urgench	Navruz	urban	8	42
Urgench	Yangi Khayot	urban	3	18
Urgench	Yangi Obod	urban	1	11
Urgench	Yukoribog	urban	2	16
			171	1148

Appendix 9.9 Instructions for behavior during interviews

INTRODUCE YOURSELF AND THE STUDY IN THE FOLLOWING WAY:

Good morning/afternoon I am [your name] from the University of Urgench. The University of Urgench is conducting in collaboration with the Center for Development Research in Bonn (Germany) a research project on waterborne infectious diseases and health economics. As you maybe already know, 200 households in Khorezm were selected randomly and have already been interviewed for the health economics section in winter 2003.
The purposes of the study are to develop prevention strategies against waterborne diseases and policy recommendations for improved water management and health policy. To achieve these aims detailed data on the occurrence of waterborne diseases and drinking water quality are needed. Therefore, the monitoring of waterborne infectious disease and drinking water quality is going to take place between May and July 2003.
We would be very grateful if you could support our study by reporting diarrheal diseases during this period.
Your participation in the study will contribute to development of locally adapted prevention strategies against waterborne diseases. Prevention of waterborne diseases is not only cheaper than its treatment but also helps to improve the health of population, especially of children, e.g., children who often suffer from diarrhea are more likely to also suffer from malnutrition.

SHOW DIARRHEA DIARY AND PROCEED IN THE FOLLOWING WAY:

1. If you agree, I would like to explain to you and the other family members, especially to those person/s who usually care for the children under seven, the self-reporting sheet. Ask her/them to join the conversation. IN CASE YOU ARE OFFERED A CUP OF TEA OR SOMETHING ELSE, PLEASE ACCEPT IT!
2. EXPLAIN THAT EVERY ADULT SHOULD INDICATE DIARRHEA INCIDENTS WITH ONE MARK PER DAY. ADDITIONALLY, NAUSEA AND VOMITING SHOULD BE INDICATED WITH THE RESPECTIVE

SYMBOL. POINT OUT THAT IT IS IMPORTANT TO MARK THE DIARY ON THE DAY OF OCCURRENCE.

3. ASK THE PERSON/S WHO CARE USUALLY FOR THE CHILDREN UNDER SEVEN TO PAY ATTENTION TO DIARRHEA INCIDENCE IN CHILDREN AND TO REPORT IT.
4. TURN OVER THE SHEET AND EXPLAIN DIARRHEA AS IT IS GIVEN THERE.
5. FILL IN THE NAMES OF HOUSEHOLD MEMBERS IN THE SHEET FOR THE 20TH CALENDAR WEEK STARTING WITH THE HOUSEHOLD HEAD. CONTINUE WITH OTHER ADULTS AND THE CHILDREN. TELL THEM THAT THEY SHOULD START THE SELF-REPORTING WITH THIS SHEET. THEN FILL IN THE NAMES INTO A SECOND SHEET FOR THE 21ST WEEK AND EXPLAIN THAT THEY SHOULD CONTINUE THE SELF-REPORTING IN THE 21ST WEEK WITH THIS SHEET.
6. TELL THEM THAT YOU WILL COLLECT THE SHEET EVERY WEEK. EXPLAIN ALSO THAT ALL DATA WILL BE USED ABSOLUTELY ANONYMOUSLY; THEREFORE EVERY HOUSEHOLD MEMBER WILL BE IDENTIFIED BY A CODE.

AFTER EVERYTHING IS CLARIFIED TELL, PLEASE SAY: **Thank you very much for your collaboration. In case you have further questions do not hesitate to contact our project office. I am looking forward to our meeting next week.** HAND OVER INFORMATION SHEET ON STUDY.

Appendix 9.10 Official information for study participants

Dear participant of the study,

For several years, Khorezm Oblast has experienced an increase in illnesses such as respiratory diseases, hepatitis and anemia and thus a decline in the health of the people. Germany, represented by the Center for Development Research (ZEF) of the University of Bonn, the United Nations Educational Scientific and Cultural Organization and both the Ministry of Agriculture and Water Resources and the Ministry of Higher Education of Uzbekistan therefore signed in January 2002 the implementation of an integrated and extended research program.

Local scientists from Tashkent and Urgench State University and international scientists from Germany work hand-in-hand in these research efforts and, among others are carrying out a scientific study on infectious gastro-intestinal diseases and health economics. Especially the health of children, who are the most vulnerable group, regarding infectious gastro-intestinal diseases and its consequences like malnutrition, has to be protected. The purposes of the study are to develop strategies for preventing against gastro-intestinal diseases and policy recommendations for improved water management and health policy. However, the definition of an improved policy and strategy must have a scientific basis, which can be reached only by an increased understanding of the environment and the scope of the consequences, which is a precondition for improving the living situation of the people.

To achieve these aims, detailed data on the occurrence of infectious gastro-intestinal diseases, drinking water quality and socio-economic health constraints are needed. In collaboration with the local authorities in Urgench, 200 households located throughout Khorezm have been selected and interviewed by the health economics section in winter 2003.

The monitoring of infectious gastro-intestinal diseases and drinking water quality is going to take place this year between May and July.

We ask your assistance and support of this important health study by providing self-reporting of diarrheal diseases during 3 months only. The self-reporting sheets will be collected and re-distributed every week by staff of the University of Urgench. For the clarification of the causes of diarrhea incidences, from time to time some additional questions will be asked by our colleagues.

It goes without saying that only with information obtained via your collaboration and participation in the study it will be possible to develop an adequate and feasible strategies to prevent infectious gastro-intestinal diseases. The use of improved strategies will help your family and particularly your children to be healthier. As with every other disease, the prevention of infectious gastro-intestinal diseases is cheaper than its treatment.

Last but not least, all information collected and provided by you will be used absolutely anonymously; therefore every household member will be identified by a numeric code and not by names. During the survey, our colleagues will inform you about the results on a regular basis and by the end of the survey, they will provide a preliminary result to each of the participants.

In case you have further questions, you are welcome to ask for further information at our project office (phone 362-22-62119) at any time.

Yours sincerely

Dr. John Lamers
Center for Development Research

Dr. Rusimboy Echschanov
Urgench State University

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