University of Hohenheim
Institute for Plant Production and Agroecology
in the Tropics and Subtropics
Department of Agroecology

Pharmaceuticals in human sanitary products for use in tropical agriculture- Case study at the Valley View University in Accra, Ghana

Master Thesis by
Evren Sinar

Egilolfstrasse 59
70599 Stuttgart

Supervisor:
Prof. Dr. Joachim Sauerborn

Hohenheim, April 2008

The project was financially supported by the Federal Ministry of Education and Research (BMBF) within the project "Ecological development of Valley View University, Accra, Ghana".

ABSTRACT

Pharmaceutical products are used in the treatment of diseases and for protection of human health. Several pharmaceuticals show biological activity after being excreted with urine and faeces. In the last few decades, various pharmaceutical residues have been detected around the globe and there is concern, they will have further effects in the environment. At Valley View University (VVU) in Ghana, human waste products are reused to fertilise and irrigate the surrounding fields. Potential pharmaceutical residues are of concern. Major diseases in Ghana differ to other countries such as Germany and influence the composition of the drugs consumed. The drug consumption in the Greater Accra region under consideration of rural, semi-urban and urban areas was examined. In addition, interviews on the campus and group discussions in rural settings were carried out, to find out about differences and similarities of drug consumption in comparison to the urban areas. In comparison to Germany, malaria and infectious diseases were more widespread and reflect the drugs needed. Similarities can be seen in the emerging of lifestyle related diseases such as hypertension or non-insulin-dependent diabetes mellitus. In interviews at VVU and in the rural settings, consumption of drugs against cardiovascular diseases, antidiabetic drugs, antiretroviral drugs against HIV/AIDS and hormonal contraceptives could not be observed. Pharmaceuticals with a potential relevance in the environment at VVU include diclofenac, ibuprofen, metronidazole, azithromycin, erythromycin, tetracycline, sulfamethoxacole, trimethroprim, sulfadoxine, ciprofloxacin, amodiaquine, lumefantrine, albendazole, mebendazole and clotrimazole.

Keywords: Drug consumption, Ghana, pharmaceutical residues, human waste products

Declaration

I hereby declare that my thesis is written by me and is a result of my own work. Any parts that refer to works of others are stated in the text and in the reference list. I guarantee that this thesis has not been used for another exam at another university in Germany or another country.

Evren Sinar

Hohenheim, the 14.04.2008

Dedications

First of all I would like to thank to the whole project team in Hohenheim for providing me the great opportunity to take part in an EcoSan project in Ghana. Many thanks go to my supervisor Prof. Dr. Joachim Sauerborn for the very interesting and challenging topic, encouraging words and support during this project and to Dr. Jörn Germer and Dr. Jan Grenz for their support and advice during this time.

I would also like to thank Dr. Seth A. Larea, Dr. Dziedzorm R. Asafo and Mr. Emmanuel Kwandahor for making this study possible at the Valley View University in Ghana. Many thanks are extended to all the staff in the visited pharmacies in and around Accra who kindly provided data and information; the Food and Drug Board in Accra; Mr. George Ousei for the field trip to the wholesale company; the health specialists Dr. Emmanuel Opare-Abjei at the Airport Clinic; Mrs. Irene Agyemang and Raymond Tetteh and the Family Planning Department at Korle-Bu Hospital; the WHO Country office in Accra, the Ghana Health Service and the Ministry of Health, especially Mr. Inua Yusuf for providing me with the latest information on the health sector in Ghana; the Traditional Herbalists Association from the Northern Sector of Ghaftram in Dodowa for showing me the huge variety of herbal medicine that they had during our meeting; all the participants in the villages of Adomrobe, Ayikuma, Bawaleshi, Dodowa and Malejor; Lillian Ofidrian for varying out the translation in the villages and Mrs Lydia Andrews and Esther Buafo for their help. The students and staff at Valley View University who participated in the interviews. I would also like to offer thanks for the great time I spent with the Physical Plant Department and Louis Addy for the friendship shown to me in Ghana. Without you this work would not have been possible; neither would it have been completed. I'm therefore very grateful.

For support shown to me throughout the completion of my thesis in Germany, I would like to thank Rainer Laue for providing me with ideas for the group discussions in the villages in Ghana; Dr. Werner Philipp from the Department of Animal Hygiene at the University of Hohenheim for the large amount of literature, which he supplied to me. Martina Winker from the TUH Hamburg for her interest and help. Mrs. Stephanie Bügler-Mietens for her help. My parents for their patience and support during my studies.

Finally, I would like to thank the Centre for Alternative Technology in Wales where I was a volunteer in 2001 and for the Josh Brown bursary, which funded my courses during my internship there. Since then, I have been fascinated by dry toilets, which is the main reason why I came across with this project in Ghana.

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Abbreviations

ACE	Angiotensin Converting Enzymes
ACT	Artemisinin-Based Combination Therapy
CVD	Cardiovascular Diseases
EcoSan	Ecological Sanitation
EML	Essential Medicine List
GHS	Ghana Health Service
IUD	Intertaurine Devices
Log_{pow}	Octanol/Water Partition Coefficient
MoH	Ministry of Health
NGO	Non-Governmental Organization
PhaR	Pharmaceutical Active Residues
RESPTA	Re-use of Ecological *S*anitation Products in Tropical Agriculture
RMS	Regional Medical Store
STG	Standard Treatment Guidelines
STP	Sewage Treatment Plant
URI	Upper Respiratory Diseases
VVU	Valley View University
WHO	World Health Organization

1 Introduction

Pharmaceutical products are used in large quantities worldwide, playing an important role in the diagnosis, treatment and prevention of diseases in human and veterinary medicine. Pharmaceuticals have always been regarded as products, which benefit humans, and not necessarily as harmful substances.

In recent years, the occurrence of micropollutants in the environment, which originate from pharmaceutical products, has received increasing attention (Jones et al., 2001). In several European countries and in the United States, this has led to the discussion of further effects on the environment through active pharmaceutical residues (Kümmerer, 2001; Jjemba, 2006; Heberer, 2002). In animal husbandry, manure is used as a nutrient source in agriculture. It is suspected that antibiotics used in veterinary medicine and which are still present in animal manure change the microbial fauna in the soil and can trigger resistance in pathogenic organisms (Fendt, 2003).

At Valley View University (VVU) in Ghana, where this study was conducted, Ecological sanitation (EcoSan), which involves the reuse of human waste products in agriculture, is practiced. The growing awareness of active pharmaceutical substances in the environment has led to the discussion, whether relevant loads in the collected human waste at VVU can be expected.

Several publications and research projects have focused on excreted active pharmaceutical residues in Germany (Kümmerer, 2001; Heberer, 2002), other European countries such as Great Britain, Sweden and Spain (Jones et al., 2001; Halling-Sorensen et al., 1998; Gomez et al., 2007) and the United States (Jjemba, 2006). Very little has been reported, on the occurrence of active pharmaceutical residues in tropical countries.
Climatic, environmental and socio-economic conditions influence the incidence of diseases most common in Ghana, which differ from those to temperate-climate and developed zones such as Germany. Therefore, it is expected that a variation exists in the requirement and use of pharmaceutical products in both areas and as a result, in the composition of active pharmaceutical residues.

In this study, the consumption of active pharmaceutical substances, measured over a one-year period in the Greater Accra region, was estimated with regards given to rural and semi-urban areas and the metropolitan of Accra. Interviews on the campus at VVU and group discussions in the villages close to the campus were held to find differences in drug consumption in rural and urban areas.

The pattern of drug use could be used as an indicator to conclude, which pharmaceutical products were regularly needed, and to allow identification of their presumable pharmaceutical active residues (PhaR) in the environment.

The objective of the study was to identify residues with potential relevance on the environment at VVU, which are to be considered as a staring point for further investigations.

1.1 Site characteristics of Ghana

Ghana is a tropical country situated on the west coast of Africa. It is surrounded by its neighbouring countries Cotê d' Ivoire in the west, Togo in the east and Burkina Faso in the north (Fig.1). It is divided into ten administrative regions: the Ashanti, Brong Ahafo, Central, Eastern, Greater Accra, Northern, Upper East, Upper West, Western and the Volta Region.

Fig.1: Map of Ghana (Central Intelligence Agency, 2007)

In this region the climate is characterised by two seasons: the rainy season that lasts from the end of May until October, and the harmattan which occurs from December until March, in which a hot wind blows from the Sahara. This lowers the humidity and distinguishes the dry season. The average annual temperature in Accra is approximately 26.4 °C (Germer and Sauerborn, 2007). In 2007 Ghana's population was around 22 million (WHO, 2007a), and comparatively young, with 46 % of the population below 15 years of age. Life expectancy is 57.6 years (WHO, 2002). Almost 60 % of the population live in rural areas. On average, 77 people living on each km^2, although the number ranges from 897 in the Greater Accra region in the south to 31 people in the Northern Region. Population growth is 2.2 % p.a. and the total fertility rate of 4.1 is similar to that

of other sub-Saharan countries. The major ethnic groups in Ghana are the Akans, Ewe, Mole-Dagbane, Guan and Ga-Adangbe. The Ga people are present in southeast Ghana, Accra the capital, and its coastal area. Besides Islam and African traditional beliefs, Christianity is the dominating religion in Ghana. The illiteracy rate is 26.2 %.

Ghana's economy is based on natural resources such as gold, timber, industrial diamonds, cocoa and increasingly, tourism. The agricultural sector in which small-scale farming is dominant absorbs 60 % of the total adult labour force. Ghana's gross domestic product is 2,370 U.S. Dollars per capita per year, which is higher than other West African countries such as Nigeria with 1,040 U.S. Dollars per capita per year, but lower than developed countries such as Germany with 29,210 U.S Dollars per capita for the year 2005 (WHO, 2007a). A low purchasing power may result in a lack of food, water, education and healthcare, and hence malnutrition, which weakens the immune system and induces susceptibility to infectious diseases. This is then lowering the manpower required for employment (Boadi and Kuitunen, 2005).

1.2 Exposure pathways and potential effects of pharmaceutical residues

Besides Ecological Sanitation that is practised at VVU, human waste products are discharged into a sewage treatment plant or enter the environment without any treatment. At VVU, the main pathways for the pharmaceutical residues are divided into different source streams. At the dormitories on the university campus, grey water, which consists of used water from washing basins and showers, is used to irrigate the fields. Active pharmaceutical substances, ingredients of ointments and antiseptic soaps used in personal care can enter with greywater into the environment. Special urine diversion toilets collect urine and urine water mixtures, which are then used as a fertiliser. The other human waste products mixed with water then flow into a biogas digester where it is used for biogas production. Effluent from the biogas digester is composted and then distributed as fertiliser on the fruit orchards and trees around the campus.

Pharmaceutical products used in human medicine such as tablets, syrups and injections undergo two main pathways in the body before they are excreted with urine, faeces or a combination of both. Firstly, some active pharmaceutical substances can be transformed via oxidation, hydrolysis or reduction. Secondly, other substances must be conjugated with sulphur or glucuronacid, in order to gain hydrophilic properties before they can be easily excreted (Sattelberger, 1999; Fendt, 2003). Following excretion, metabolites or drug residues are ideally mineralised by microorganisms to carbon dioxide and water.

The majority of drug residues can have further effects on the environment depending on their physical and chemical properties such as the chemical structure, octanol/water partition coefficient (log $_{pow}$) or aqueous solubility (Jones et al., 2005). Other pharmaceuticals show persistent characteristics such as tetracyclines (Höper et al., 2002) or cotrimoxazole (Peschka et al., 2007). Investigations in Germany have revealed that plants such as winter wheat (*Triticum aestivum* L.) or lettuce (*Lactuca sativa* L.) were able to absorb antibiotics through their roots and transport them into the plant

and even into the grain (Grote et al., 2005), which indicates absorption and persistence of some PhaR.

Not ideally, metabolites are not readily biodegradable and may persist on organic matter e.g. sewage sludge or soil if lipophilic. Metabolites with hydrophilic but persistent properties are likely to reach water sources (Halling-Sorensen et al., 1998). The octanol/water partition coefficient ($\log_{pow}$) is an important parameter in describing the ability to dissolve a chemical substance between the aqueous phase and organic biomass. The higher the coefficient is, the stronger the tendency of a substance to be adsorbed onto organic matter. A low coefficient of the chemical indicates a more hydrophilic character; it will be more likely found in the aqueous phase (Jones et al., 2005).

Other drug residues, for example ethinylestradiol from oral contraceptives, have endocrine effects. In male rainbow trouts living close to effluent discharge of sewage treatment plants, which were exposed to the synthetic hormone ethinylestradiol, increased the production of the hormone vitellogenin, which is usually responsible for fish-egg development (Solomon, 2005).

Furthermore, drug residues at high concentrations can have toxic effects, e.g. on *Daphnia magma*, algae, bacteria and fish in the aquatic environment (Kümmerer, 2001).

If antibiotic residues are applied to the soil, they may interact with the soil fauna. In such cases, mutations of the microorganisms can lead to acquired resistances and further spread these properties. This development results in the ineffectiveness of antibiotics on pathogenic organisms (Sattelberger, 1999).

Furthermore, various influences such as microorganisms in the soil, chemical and photo-induced processes (Kreuzig et al., 2003), as well as temperature (Boxall et al., 2004) and ozone (Ternes et al., 2003) can destroy functional groups or reduce the half-life of the PhaR that will eventually degrade.

Around 3,000 active pharmaceutical substances are on the European market (Ternes et al., 2004), of which 120 substances are detected in matrices such as sewage effluent, surface water or soil, and a further 30 have been proven to show relevant impacts on the environment (SRU, 2007).

1.3 Health characteristics

For investigating the possible exposition of PhaR in the environment, it is of relevance to examine the major diseases, which occur in Ghana, in order to recognise possible pharmaceutical products used. Ghana, like many other sub-Saharan countries, is faced with epidemic diseases, i.e. the predominance of communicable diseases, under-nutrition and poor reproductive health, with an emerging importance of non-communicable diseases such as diabetes, cardiovascular diseases (CVD) and neoplasm (WHO, 2002). The tropical climate provides optimal living conditions for vectors like mosquitoes, which spread malaria. In less-developed areas, poor waste disposal practices including dumping of household rubbish in open spaces or open sewers, leads to runoff which then contaminates surroundings and water resources (Boadi and Kuitunen, 2005). Contaminated potable water is the source of many diseases transmitted by pathogenic microorganisms. Data concerning the drinking-water situation in Ghana shows that 73 % of the population have access to safe drinking water in 2000. Therefore, since 1990, when only 53 % had this access (UNICEF, 2003), a significant improvement has taken place. According to the Ghana Health Service (GHS), the major health problems in Ghana are malaria followed by acute respiratory infections and skin diseases. The major diseases are listed in Table 1 and their relevant medical treatment options will be discussed in the study.

Table 1. Major diseases in Ghana (GHS, 2005a)

Major diseases in Ghana in percent[1]	%	Total in cases
1. Malaria	43.7	3,799,158
2. Acute respiratory infections	6.7	581,323
3. Skin diseases and ulcers	4.0	352,295
4. Diarrhoeal diseases	4.0	352,384
5. Hypertension	2.9	249,342
6. Acute eye infection	2.2	190,293
7. Pregnancy-related complications	2	172,253
8. Rheumatism and joint pains	1.9	162,162
9. Anaemia	1.7	144,606
10. Intestinal worm infestations	1.5	134,440
11. Others[*]	29.4	2,240,735

Diseases in Ghana differ from those in developed countries such as Germany and other European countries, where improved hygienic standards, progress in medicine and food security have reduced the prevalence of infectious and water-borne diseases. Changes in lifestyle, increase in stress and malnutrition have led to the rise of diseases such as CVD, neoplasm and adult onset diabetes (Table 2).

[1] Cases reported at outpatient departments- 2005

[*] Road-traffic, home and occupational accidents are included

Table 2. Major diseases in Germany (Spielmanns-Jacobs U., 2005)

Major diseases in Germany as percentages	%
1. Cardiovascular diseases	14.4
2. Neoplasm	9.1
3. Diseases of the digestion system	8.9
4. Diseases of the respiratory system	7.3
5. Psychological disorders	7.2
6. Diseases of the skeletal muscles	7.2
7. Genito-urinary disorders	4.9
8. Diseases of the nervous system	3.7
9. Endocrine disorders	3.3
10. Infectious and parasitic diseases	2.6
11. Others[2]	31.4

The main differences between these two countries are that malaria is absent in Germany and communicable infectious diseases do not have significant impact on the population as in Ghana. Overlapping does exist in hypertension, which belongs to CVD, and also with diseases affecting the respiratory system.

[2] Accidents are included

1.4 The pharmaceutical sector

To assess pathways of medications used, it is of interest to know where drugs can be obtained. Major players in the supply of drugs are the wholesalers and importers. Distribution is provided through retail pharmacies, chemical shops, health centres and hospitals.

Distribution of health facilities

The public health sector consists of a network of hospitals, health centres and maternity homes. Overall, more than 60 % of the population have access to health services within an hour's travel time. Although, regional disparities exist: in urban, areas about 80 % of all households have good access in comparison to rural areas with 40 %. Access was defined by the GHS (Ghana Health Service) as being within one hour's travel time from the health facility. With a travel time of 30 minutes, more than half of the population does not have access to a health facility.

In total, 2,740 health facilities exist throughout the country (Table 3). This number includes teaching hospitals in Accra and Kumasi, other hospitals, health centres and maternity homes (GHS, 2005b). The most optimal access to health care is observed in the Greater Accra region, in there more than 80 % of the households are able to reach a health facility within 30 minutes to receive medical care by any available means (Ghana Statistical Service, 2003).

According to the WHO (2004), in Ghana, 3,240 physicians wait on the population, which means that there are 0.15 doctors per 1,000 residents. The situation in Côte d' Ivoire, its neighbour country, is similar. Here, there were 0.12 physicians per 1,000 people in the year 2004. In comparison, there are 3.37 doctors per 1,000 residents in Germany.

The total number of health facilities operating in the Greater Accra region is 310 (GHS, 2005b). Further data (Yusuf, 2007) from the Ministry of Health (MoH) and the Health Directory (Oduro, 2007) show lower figures of 254 and 284 health facilities, respectively. Pharmacies are not included in these figures and are separately considered. There are 637 retail pharmacies in the country (Table 3),

of which 425 are located in the Greater Accra region (Pharmacy Council, 2006). Here, one health facility or one retail pharmacy covers an area of 4.4 km^2, whereas in the Northern region a health facility or a retail pharmacy covers 355 km^2.

Table 3. Regional distribution of pharmacies at December 2005 (According to Pharmacy Council, 2006)

Region	**Population (Census 2000)**	**Area (km^2)**	**Pharmacies Total[1] (Pharmacy Council, 2006)**	**Retail pharmacies (Pharmacy Council, 2006)**	**Health Facilities (GHS, 2005b)**	**Population per facility (Retail Pharmacy and Health facility)**
Ashanti	3,612,950	24,389	243	147	446	6,092
Brong Ahafo	1,815,408	39,557	29	3	251	7,147
Central	1,593,823	9,826	23	14	264	5,733
Eastern	2,106,696	19,323	43	15	390	5,201
Greater Accra	2,905,726	3,245	702	425	310	3,953
Northern Region	1,820,806	70,384	8	4	194	9,195
Upper East	920,809	8,842	5	2	133	6,820
Upper West	576,583	18,476	2	2	102	5,544
Volta	1,635,421	20,570	14	9	339	4,699
Western	1,924,577	23,921	38	16	311	5,885
Total	18,912,079	238,537	1,101	637	2,740	5,600

Essential medicines

In Germany, around 3,000 active pharmaceutical substances are used in more than 9,000 products (SRU, 2007). The WHO has published an essential medicine list with 300 active pharmaceutical substances present in the most elementary drugs. Similar to the WHO medicine list, the Ministry of Health in Ghana published the Essential Medicine List 2004 (EML), with the purpose of providing a guideline of elementary medicinal products used in human

[1] Total pharmacies include manufacturing wholesale pharmacies, wholesalers, wholesales with retail pharmacies and retail pharmacies

medicine, for its respective region, to comfort the healthcare needs of the population and encourage public and private institutions to select drugs from the list. The fifth and current edition was published in 2004 and is regularly updated and expanded every four years. The drugs on this list are derived from the Standard Treatment Guidelines 2004 (STG), which is a document addressed to health specialists and shows treatment options for common diseases in the region. Most essential drugs are without a doubt present at the pharmacy market in Ghana. Although, one study conducted on the health sector found out that non-essential medicines compromise only 4 % of pharmaceutical products in hospitals (WHO, 2002).

Over-the-counter drugs

The drugs listed in the EML are grouped into different categories. They are separated into drugs that are restricted for use by qualified health specialists who may request them or can be prescribed. A large proportion of drugs are so-called "over-the-counter drugs", i.e. they are available without prescription and can be obtained in pharmacies or chemists. In addition, over-the-counter drugs not listed in the EML are also available.

Non-essential medicines

Medicines other than essential medicines have to fulfil the standards of the Pharmacy Council Act from 1994 (Act 489) and the Food and Drug Law 305B from 1996 (Food and Drug Board, 2007; Odor, 2007). The range of non-essential medicines varies from different painkillers to lifestyle drugs. More non-essential drugs will be added to the renewed version of the EML at the end of 2007 (Food and Drug Board, 2007). To date, there is no data available regarding the range of active pharmaceutical substances of the non-essential medicines currently in use.

Distribution of drugs through hospitals

The availability and accessibility of drugs is an important objective of the national drug policy in Ghana (Oduro, 2007). To provide a constant stock of pharmaceutical products for all health facilities, a decentralisation of the drug distribution is practised. Regional medical stores (RMS) receive drugs through

international bids and local suppliers in the private sector, e.g. wholesalers or manufacturers. They in turn deliver the drugs to regional hospitals (WHO, 2002). RMS store only drugs listed in the Essential Medicine list 2004 (Bosu and Adjej-Ofori, 2000). Non-essential drugs have to be purchased privately from local suppliers or are imported. For estimating the consumption amounts of the predominately used pharmaceutical products in the study area, which can have further effects in the environment when excreted from the human body, an appropriate and feasible method was needed. According to the WHO standard methodology, on how to investigate drug use, 20 health facilities in each region were suggested as places to visit (WHO, 1993).

Pharmacies provide an important source of dispensing drugs for Ghanaians and are listed in the directory by the Pharmacy Council in Accra, Ghana (Pharmacy Council, 2006). The list consists of licensed pharmacies nationwide. Pharmacy facilities are classified into manufacturing wholesale pharmacies, wholesale pharmacies, wholesale and retail pharmacies and retail pharmacies.

The pharmacies chosen for this study concern the Greater Accra administrative region. Here, the regional distribution of these facilities is comprised of 11 manufacturing wholesale pharmacies, 94 wholesale pharmacies, 167 wholesale and retail pharmacies, and 425 retail pharmacies[2]. For this study, only retail pharmacies were considered as they obtain drugs from the wholesaler or from the manufacturers. Drugs can also be obtained from chemical sellers in places where no pharmacists are operating. These facilities were not considered in the sample size because their number was unknown.

The main performers at the end of the supply chain were the pharmacies and health centres. Their total number in the region was available and a separation between rural, semi-urban and urban areas shows differences in the use of pharmaceutical products. For data collection, it was essential to limit the substances, which were distributed in the pharmacies for convenience of the

[2] Retail pharmacies refer to all pharmacies that sell pharmaceutical products individually or in small quantities to the public. It is registered in accordance with Section 28 of the Pharmacy Act, 1994, Act 489.

participants. Therapeutic groups with the active pharmaceutical substances were listed. According to the major diseases in Ghana in 2005, and the Standard Treatment Guidelines, the following therapeutic classes listed in Table 4 were highlighted. In additional, contraceptives were considered due to their endocrine activity in the environment. According to a survey in 2002 (WHO, 2002), neoplasm, and diabetes is on the increase in Ghana, and therefore therapeutic drugs in neoplasm and non-insulin-dependent diabetes were requested. Antiretroviral therapy has been of interest. The HIV/AIDS prevalence among young adults aged 15 years and over in the Greater Accra region is estimated to affect a maximum of 66,750 people (WHO, 2005). If these affected people regularly use drugs in the treatment of HIV/AIDS, this may be a potential threat in the ecosystem after its excretion.

Table 4. Therapeutic groups used in the treatment of major diseases and for prevention in Ghana (MoH, 2004b)

Major diseases	**Therapeutic group**
Malaria	Antimalarials, antipyretics[3]
Acute respiratory infections	Antibiotics
Skin diseases and ulcers	Ointments
Diarrhoeal diseases	Drugs used in diarrhoea
Hypertension	Cardiovascular drugs
Acute eye infection	Antibiotics
Pregnancy-related complications	*
Rheumatism and joint pain	Analgesics[4], anti-inflammatory drugs
Anaemia	Dietary supplements
Intestinal worm infestations	Antihelminitics
Additional therapeutic groups in disease conditions and prevention	
Diabetes	Antidiabetic drugs
Contraceptives	Hormones
HIV/AIDS	Antiretroviral therapy
Neoplasm	Antineoplastic and immunosuppressive drugs

[3] Drugs that reduce fever
[*] Not considered in this study
[4] Drugs used to relieve pain

Dietary supplements, oral rehydration solutions and insulin were not relevant in the questionnaire. It is suspected that nutritional elements do not have further effects on the environment due to their natural structures (SRU, 2007). Coughing syrup was rarely stated.

2 Material and methods

2.1 Research area and sample size

The Valley View University (VVU) is located in the Greater Accra region close to Oyibi, and also 31 km from the city of Accra, and 13 km from Adenta, a suburb of Accra (Fig. 2). The campus lies next to a main asphalt road, which connects Accra to the south and Lake Volta in the north. Rural and semi-urban areas can be found in the surrounding areas of VVU. Urban structures are dominating in the areas close to city of Accra.

Fig.2: Location of Valley View University (RESPTA, 2007)

The VVU is a Seventh-day Adventist institution, a Christian denomination established in the 19th century in the United States. It is Ghana's oldest private university, and hosts up to 2,000 students and 200 workers. In the forthcoming years, the university is expecting to expand to up to 5,000 students. An ecological concept has been created in cooperation with the University of Weimar, the German Ecological Engineering Society, the University of Hohenheim and private companies. The aim is to fulfil the growing demands of

energy and water by the students and to minimise the ecological impact. The VVU, where the study area is located, lies within the coastal savannah zone, which is the scarcest region of water in Ghana (Germer and Sauerborn, 2007).

Therefore, an innovative water-saving and nutrient-recycling concept for human waste has been introduced, which is referred as ecological sanitation (EcoSan). Wastewater is source-separated into pure urine and a urine-water mixture (yellow water), water from baths and kitchens (grey water), and black water in which faeces from the toilets are mixed. On the university campus, special water-saving separating toilets collect the urine and urine-water mixture, which is then stored for six months. In tropical climates, higher temperatures may increase the inactivation of pathogens in a shorter period of time. This time allows the elimination of *Schistosoma haematobium* or *E.coli* and other pathogenic organisms (Höglund, 2001). Following this storage stage, it is applied as a fertiliser in the surrounding fields. The black water mainly consists of faeces and is used for biogas production. The biogas effluent is applied to trees in the surrounding orchards (Germer and Sauerborn, 2007). The grey water is used for irrigating annual and perennial crops. In this order, EcoSan recovers the soil from nutrient losses through agriculture, preserves its fertility and saves water (Germer and Sauerborn, 2007).

2.1.1 Estimation of drug use in the Greater Accra region

The estimation of drug use has to be considered as a stratified sample size. The number of retail pharmacies, which were considered in the sample size, is 425. From this number, 180 were located in urban areas. Approximately 235 pharmacies were located within the suburbs of Accra, whereas only 10 pharmacies were located in rural areas. A higher concentration of pharmacies was observed in the city and suburbs of Accra. Distance to the city centre was a criterion for defining the urban, semi-urban and rural areas. In the suburbs of Accra, it is possible to find several pharmacies along a main road, whereas in the city centre, there are numerous pharmacies to be found. In rural areas pharmacies and health centres are quit scarcer. For data collection, it

was aimed to visit 20 facilities in rural, semi-urban and urban areas in the correspondent study area.
In each pharmacy, the pharmacist responsible for the store or another member of the medical staff was asked as to whether they would be willing to provide time and information for the research. The questionnaire was filled out on-the-spot or was left to be picked up at a later time. The sum of drugs per week is then divided by number of pharmacies visited and multiplied by the total number of pharmacies in the corresponding area (Piepho, 2007). The outcomes will be calculated over a one-year period, with the appropriate drug in kilograms. For data analyses figures were imported from Excel into SAS 9.1. The procedure has also been suggested by the WHO standard method (WHO, 1993). To confirm the reliability of the data, confidence intervals were calculated.

Roughly 310 health centres are located in the Greater Accra region (GHS, 2005b). Hospitals, health centres and clinics in rural, semi-urban and urban locations were chosen randomly by asking pedestrians. The addresses are listed in the appendix. It was aimed to visit 15 health centres in the Greater Accra region and to calculate the amount of the major consumed drugs in kilogram per year.

2.1.2 Estimation of drug use in rural and semi-urban areas

People in rural and in urban regions are considered to have a different drug-use pattern due to their different socio-economic status, education, sources of knowledge in traditional medicine, availability as well as the affordability of drugs. The consumption of pharmaceutical products depends on a variety of factors. People in rural areas face longer distances, in order to access a health facility (Ghana Statistical Service, 2003) such as pharmacies or health centres.

Focus-group discussions took place in the villages. The method consists of discussion with the participants, with the aim of gathering information regarding common diseases in the community, and their medical treatment. The discussions were held separately in according to gender. The discussions were

carried out by a team of three individuals including an interpreter, presenter and a helper together with the residents and were conducted for up to two hours in each village. Prior to conducting the discussions, a meeting took place with the village chief, in order to obtain permission and to explain the purpose of the gathering, and to find suitable time and space. A seasonal calendar was prepared, which illustrates the rainy and dry season in accordance to the traditional calendar (Fig. 3). The objective of this calendar was to identify whether the occurrence of diseases is related to seasons, and if the consumption of medicinal drugs accordingly varies. Participants were asked to place groundnuts in the departments of the seasonal calendar when they suffer from diseases. Following the rating, discussions then commenced on the respective health problems.

Fig.3: Example of a seasonal calendar

2.1.3 Investigating drug consumption at Valley View University

At the time of investigation, 1,932 students were enrolled, of which 1,251 were men and 681 women. A staff of 209 is involved in management and teaching. The students have the option to study business, accounting, computer sciences, religious studies, theology and optional courses in languages, history, education and marketing. The courses are divided into two academic terms within the year, and in between, summer school is held. The interviews took place during this time. Questions were asked orally and answers were noted. Students and workers could respond to the questions and had enough time to

explain the diseases and drugs used. The interviewed person was asked what diseases they had had in the last six months. The disadvantage of the method of questioning was that the interviewed person could not remember the name of the drugs. Secondly, the interviewed person was asked what kind of drugs they usually kept in their household for use. Besides these two questions, demographic characteristics such as age, sex and profession were asked. Data was entered into SPSS 12.0 (Statistical Package for the Social Sciences for Windows) and then imported into Excel to illustrate the responses. A mask with the following variables was prepared: antimalarials, analgesics, antibiotics, antihelminthics, antidiarrhoeals, laxatives, antihistamines, contraceptives, herbal medicine, dietary supplements and other various medicines. Furthermore, the variables were divided into their active pharmaceutical compounds.

3 Results and discussion

3.1 Estimation of drugs applied in the Greater Accra region

From 30 visited pharmacies, seven pharmacies in the city of Accra, eight in the semi-urban and two in the rural area provided data for this study. The visits took place between the 15th of May and 15th of August. The WHO method recommends that 20 health facilities in urban, semi-urban and rural areas are necessary. It was not feasible to visit more pharmacies due to time restrictions and a lack of cooperation with the health facilities. The names and locations of the pharmacies are listed in the appendix. The pharmacies in urban and semi-urban areas were chosen randomly by asking pedestrians for the closest pharmacy and reached by feet and public transport.

Active pharmaceutical substances were calculated for a one-year period for the Greater Accra region in regard to rural, semi-urban and urban locations. In this study, pharmacies and health centres were visited. It was observed that in three village drug stores provided some drugs and offered primary health care. These places were not licensed, but can receive drugs from the wholesaler, retailer or from donations. Drugs dispensed by the village drug stores are often obtained from retailers and these data would bias the estimations because the drugs by the retailers are considered separately. The values of the following therapeutic groups provide an overview on the major substances used in the study area. Various amounts of drugs are brought into the country by aid -organisations, missionary sources or by counterfeit drug dealers, which were also not considered in the study.

In Accra, drugs are quite commonly sold on the street as illustrated in Fig.4. These most probably originate from the wholesaler or the manufacturer of the drugs who sell them directly to individuals for further distribution. Among them, antihelminthics such as albendazole or painkillers with diclofenac or ibuprofen were sold. This practice is due to the lack of storage facilities and irrational use prohibited (Food and Drug Board, June 2007).

Fig.4: Sales-man in Accra offering albendazole and ibuprofen

Counterfeit drugs from Asia reach the country e.g. chloroquine "Made in China". The substance is normally produced in Ghana itself through imported raw materials and not allowed to be imported (Food and Drug Board, 2007). The majority of the drugs distributed in the hospitals and pharmacies are similar to the EML 2004. In fact, a great proportion of the distributed drugs in hospitals and clinics are received by the RMS, which has only drugs in their stock listed in the EML 2004. Drugs not listed in the EML are referred as non essential drugs and are distributed in lower amounts in hospitals, because they have to be obtained separately from the wholesaler, manufacturer or importers.

But among the non essential drugs casually irrational drugs are to found and advertised in health centres and pharmacies in Accra. Examples for irrational drug use were Xenical® for obesity or other drugs like piracetam used as brain enhancers in Alzheimer's disease, which are mainly imported and advertised throughout pharmacies and hospitals in the metropolis of Accra (Fig.5). According to the main objectives of Ghana's National Drug Policy, it is to ensure the availability and the rational use of essential drugs to the population (Oduro, 2007). However, obesity does not belong particularly to the major health problems at the time of study in Ghana. But poor patient management practices including diagnosis, prescribing and dispensing results in irrational drug use (Oduro, 2007). Irrational drugs represent wastage of resources such

as money, storage, and distribution and eventually remainders of PhaR, which enter the environment by human waste or its disposal.

Fig.5: Lifestyle drug commonly sold in Ghana as "brain enhancer"

It is estimated that are 210,000 to 560,000 people infected with the HIV/AIDS in Ghana, but most of the interviewees negate drugs for neoplasm and HIV/AIDS and as discussed in chapter two antiretroviral therapy is available for 5.8 % of the patients (WHO and UNAIDS, 2005). Also drugs used in neoplasm are marginal, although the MoH claims that neoplasm is emerging (WHO, 2002).

Gathered data of the drugs used in this study varied strongly. The pharmacy market itself in Ghana undergoes high fluctuations. According to (Bosu and Adjei, 2000) drugs supply depends often on world market prices and the next appropriate drug that can replace the substance is chosen. Seasonal variations in diseases and prescription habits of the medical staff influence the drug use. Another reason found out during the investigations is the inconsistent donation of drugs in communities by various aid-organisations. At VVU, for example students did receive pharmaceuticals as gifts from abroad or get unknown pharmaceuticals from medical check-ups of missionary doctors. The drug supply determines the demand (Fig.6), which made it difficult to estimate the commonly used drugs.

Fig.6: Donated unlabelled drugs handed out during medical check-up at VVU

Incomplete data obtained through the visits at the health facilities have been another difficulty. Active pharmaceutical substances were missing or were not dispensed frequently at the place. Therefore the significance between the single substances is very low and gives only rough estimations of the consumption amounts.

Nine health facilities within hospitals, health centres and clinics in rural, semi-urban and urban areas have been visited. The majority of the listed facilities had to be visited several times to collect the required information and to meet the right persons in charge. In general there has been a lack of cooperation by the medical staff.

From health centres visited, it was possible to gather information of one clinic and the Korle-Bu teaching hospital. In both facilities the first top ten diseases and their treatment options were asked. The complete data can be taken from the appendix. A rough estimation for the urban area has been calculated for a one-year period, through the data of drugs dispensed in 2005. Active pharmaceutical substances were given in kilogram per year. Data were not reliable for all health centres but show tendencies for the consumption of pharmaceuticals.

3.1.1 Analgesics

It is estimated that 440 kg of acetylsalicylic acid, 350 kg of diclofenac, 1,670.5 kg of ibuprofen and more than 3,814 kg of paracetamol is sold by pharmacies in the Greater Accra region per year (Fig.7). Additionally 9.6 kg naproxen, 3.5 kg piroxicam and 5.2 kg of indometacin were sold per year. Doses and confidence interval can be obtained from the appendix. In hospitals and health centres no acetylsalicylic acid was used. Here the substances were paracetamol followed by ibuprofen, diclofenac and naproxen to a lesser extent. 37,780 kg of paracetamol, 4,868 kg of ibuprofen, 1,662 kg of diclofenac and 1,327 kg of naproxen were consumed. In summary, about 50 t of analgesics were sold per year in the Greater Accra region for 3 million people. Calculating the amounts of acetylsalicylic acid, diclofenac, ibuprofen and paracetamol, Germany in comparison distributed 70 tons per year to 3 million inhabitants (Anonymous, 2007). Considering amounts from donations, NGO (Non Governmental Organization) and chemical shops, and the estimated data of 50 t per year seem justifiable and possible.

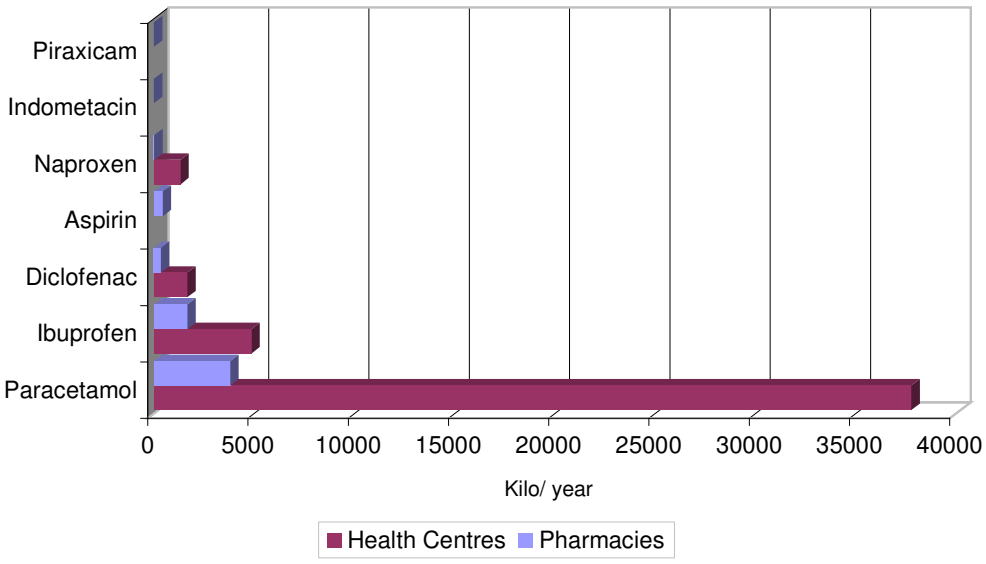

Fig.7: Sold analgesics in the Greater Accra region

Differences in the consumption of analgesics were found between rural, semi-urban and urban areas. Naproxen, indometacin, piroxicam and combinations of painkillers with caffeine or ephedrine were more likely to be found in the urban and semi-urban areas. In the rural areas, painkillers such as paracetamol and ibuprofen were dominant

Paracetamol is the most frequently used painkiller in this study. It is fairly cheap -1000 Cedis (around 10 Euro cents) for 10 tablets- and available alone or in other combinations with stimulants such as caffeine or ephedrine. There is only less data available of paracetamol in effluent from sewage treatment plants and in surface water, due to the fact that it is easily degradable. In Germany, it has never been detected in ground or drinking water. A high consumption of the particular active pharmaceutical substance does not necessarily mean that it is present in and potentially harms the environment. In activated sludge (aerobic and anaerobic) in sewage treatment plants (STP), paracetamol is biodegraded by up to 99 % in 5 days (ECB, 2000). Almost 80 % of the ingredient is metabolised in the liver and the remains are eliminated by the kidneys (Schneider and Richling, 2007).

Ibuprofen is used against fever and pain. It is excreted by up to 60-90 % in form of metabolised conjugates from the body (Schneider and Richling, 2007). Little is known about the metabolites. In urine, one percent of the consumed ibuprofen is excreted in its non-metabolised form (Anonymous, 2007). Ibuprofen is easily bio-degradable (Halling-Sorensen et al, 1998; Ternes and Römbke, 2005). Ashton et al. (2004), writes that ibuprofen is relatively persistent in aquatic systems with a half-life from less than one to 50 days. Its log P_{ow} between 3.5 and 4.5 is moderately lipophil, which means the compound is likely to adsorbed by organic matter but also present in sewage effluent and surface water (Anonymous, 2007). In various effluents from STP ibuprofen could be detected at 0.1 to 1 microgram per litre (Anonymous, 2007). The fate and effect of ibuprofen in soil and terrestrial organisms has not yet been investigated, but its property to be adsorbed by organic matter, indicates a potential to accumulate which has to be considered. The estimated amounts with more than

6,000 kg per year the substance gain importance and needs further investigations in Ghana.

Acetylsalicylic acid, better known as aspirin, was only less dispensed in the health facilities in Accra. It is degraded by photo-oxidation. Regarding the fate and behaviour of acetylsalicylic acid, it is mineralised in carbon dioxide and water and has no further relevance in the environment (Halling-Sorensen et al., 1998).

The substance diclofenac was responsible for the deaths of vultures in India and Pakistan. The vultures were feeding on dead corpses of cattle, which had been treated with diclofenac before (Taqquart et al., 2007; Fendt, 2006). Diclofenac is also known to show sub-lethal effects on trouts. However, actual data on the substance lead to no ecotoxicological effects in chronically exposure towards *Daphnia magna*, algae and fish (Rohweder, 2003). Diclofenac is used in rheumatism and joint pain. It is excreted up to 1 % in its pharmaceutically active compounds, and conjugated metabolites from the excretion show no pharmacological potential. The metabolites are excreted 70 % via urine and 30 % over the faeces. Diclofenac shows a poor biodegradability in water but degradation via radiation plays a major role (Estevez et al., 2005). Diclofenac is rather fat-soluble and can be adsorbed easily to organic matter especially under acidic conditions. Neutral and alkaline conditions provide better conditions to degrade but then again metabolites can leach easier into groundwater (Anonymous, 2007). Also Heberer (2002) mentions a low removal rate in wastewater treatment but emphasises the possible photodegradation of diclofenac. Ashton et al. (2004) on the other hand argue that diclofenac is rapidly degraded in the environment. Half-life is less than a day and photodegradation reduces its half-life to 4 hours. Concerning its potential accumulation in soil and possible toxic effects, more research is needed.

Naproxen a strong painkiller is estimated to be sold at more than 1,300 kg per year in the Greater Accra region. In Germany, naproxen has been detected in effluent from wastewater treatment plants (Stumpf et al., 1999;

Krisstensen et al., 2007). With its log p_{ow} of 3.18 it shows moderate affinity to organic matter. In newer publications, naproxen is considered to be degraded easily by photochemical-oxidation with UV radiation and hydrogen peroxide (Felis et al., 2007). An according treatment led to the disappearance of 90 % of the active pharmaceutical substance within five minutes. Less is reported about its fate and behaviour when urine or faecal sludge is applied in agriculture. But the possible photodegradation indicates that the PhaR is eventually degraded.

Indometacin belongs to the least used painkillers in Ghana and were not available in all pharmacies. In Germany, indometacin could be detected in surface waters, effluent and to a very low extend in groundwater (Rohweder, 2003). Indometacin shows poor biodegradability and has therefore the ability to be accumulated. There is insufficient data about the behaviour of indometacin in soil (Anonymous, 2007). Due to its minor consumption indometacin is likely not to be found in human excreta in Ghana.

Piroxicam is excreted up to 5 % in not metabolised form from the body (SRU, 2007). So far, little about piroxicam and its fate or behaviour in the environment has been reported. However, like indometacin the usage of piroxicam is very low and can be neglected in further studies in Ghana.

3.1.2 Antiinfective drugs

Progress in medical science, particularly the discovery of antibiotics and better hygienic conditions have significantly reduced the prevalence of infectious diseases. Increasing use of antibiotics leads to developing resistances in pathogenic microorganisms. Irrational use of antibiotics further aggravates the situation (Schröder et al., 2004). In Europe, the consumption of antibiotics for human medication was estimated 8500 t in 1999 and additionally 5000 t in veterinary medicine (Hamscher et al., 2005). About 75 % of the antibiotics are excreted from the human body by their active pharmaceutical form of (SRU, 2007). Residues from antibiotics reach the environment via effluent of sewage treatment plants, untreated sewage or through the application of animal manure on agricultural land. In pig manure for example tetracyclines and

sulfonamides are detectable (Schröder et al., 2004). In the environment residues may influence the microbial fauna in the soil e.g. development of resistances (Rohweder, 2003; Schröder et al., 2004; Fendt, 2003).

Antibiotic drugs

If comparing the data from the Ghana Health Service and from one insurance company in Germany (Jacobs-Spielmann, 2006) in Table 2, it is recognisable that infectious diseases are dominant in Ghana. Very common are acute eye infections, upper respiratory or urogenital tract infections (GHS, 2005b). In the obtained information from health centres and hospitals 27 different antibiotic substances were mentioned. Pharmacies show a similar range of pharmaceuticals. The major difference comparing data from hospitals and pharmacies were that hospitals provide antibiotics in greater quantities and use so called "reserve" antibiotics, which were frequently used in resistance pathogens (Schröder et al., 2004). Hospitals are the main source of the antibiotic drugs in the region. Pharmacies prefer to give broadband antibiotics such as amoxicillin. Availability of antibiotics in village pharmacies such as amoxicillin or metronidazole, depend on biddings from the private suppliers (WHO, 2002) or donations from e.g. NGOs.

Total usage of antibiotics amounts to about 70 t per year in the Greater Accra region in this study. Figures from Germany were 496 t in 2001 (Anonymous, 2007). The estimated figure in this study, in comparison, is almost four times higher than in Germany. However, infectious diseases in Ghana are more common than in Europe, and considering the prescription and diagnosis behaviour of diseases, these figures show correct tendencies. A study in Germany has recognised that in southern European countries, more antibiotics are prescribed than in northern countries. At the same time, countries with a higher use of antibiotics have a bigger problem with resistances. It could be alleged that the people in southern regions tend to be more careless and easy with antibiotics (Width et al., 2004). In Africa and most other developing countries, multidrug resistances towards common antibiotics are challenging the health system. Disease outbreaks did happen because of existing multidrug resistances towards three or more antibiotics in Democratic Republic Congo,

Rwanda, Nigeria, and Malawi (Kariuki et al., 2006). Excessive uses in hospitals and over-the-counter use for self-treatment are factors pushing the development of resistances. Own experiences showed that the use of several antibiotics at once is a common practice in Ghana. The combination of different antibiotics covers a wide range of microorganisms (Schäfer, 2007). Additionally, lack of diagnosis and the prescription habits of the medical staff intensify the situation (Bosu and Adjei, 2000). There is no correlation between highly consumed drugs and PhaR in the environment, but highly used amounts can indicate possible expositions of active pharmaceutical residues in the environment (Sattelberger, 1999). The distribution of antibiotics classes used in the health facilities and pharmacies in the Greater Accra region is illustrated in Fig.8.

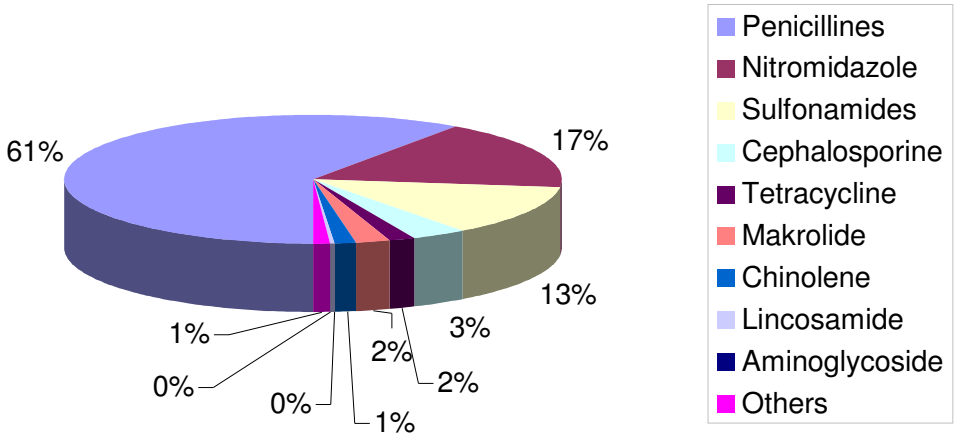

Fig.8: Distribution of antibiotic classes

Penicillines are the greatest part with almost 40,000 kg per year. They include amoxicillin, flucloxacillin, cloaxicillin and penicillin V, and the newer penicillines amoxicillin combined with clavulinic acid takes with 60 % the greatest part of all the antibiotic classes. Concerning their fate and behaviour in the environment, penicillines are known to have low relevance due to their instability. Heberer (2002), reports that penicillines could not be detected after wastewater treatment. Its ß-lactam ring is instable and can be degraded easily in the environment (Estevez et al., 2005). In a study about reuse of animal manure the

half-life of penicillines and *makrolides* was about 5-21 days. In long storage times of liquid manure, more than 90 % of the biological active metabolites of veterinary medicine in animal sludge are degraded (Sattelberger et al., 2005).

Cephalosporines are used more than 2,000 kg per year and are another antibiotic group with a ß-lactam ring, responsible for its antimicrobial activity. Like the penicillines, the active pharmaceutical substances ceftriaxon, cefuroxim, cefuroxim axetil are considered to be fragile in the environment. Cephalosporines and its metabolites are degraded by abiotic factors such as temperature or ultraviolet-radiation and biotic factors such as microbial activity in the faeces, in urine, faecal mixture and soil (Hornish and Kotarski, 2002).

Sulfamethoxacole belongs to the antibiotic class of the *sulfonamides.* Combined with trimethroprim it is used in the treatment of urogenital or acute respiratory infections. In this study, estimated, roughly 7,500 kg of cotrimoxazole per year is distributed in the Greater Accra region. Cotrimoxazole is a combination of 5 parts sulfamethoxazole and one part trimethroprim. Investigations in Germany, found out that the substance can be found in various environmental matrixes such as effluent, surface water, groundwater, or soil and can be regarded as ubiquitous. The substance is persistent and non-biodegradable in the environment. Removal by photo-oxidation is possible. Due to its very log p_{ow} of 0.89, sulfamethoxazole is water soluble and highly mobile. Sorption to soil particles is low and a possible leaching into the groundwater has to be considered. Concentrations found in the environment so far, do not harm the bacterial flora, but it is observed that bacteria strains develop resistances, if exposure follows continuously (Anonymous, 2007).

Trimethroprim in human medicine is predominantly excreted with urine. In the environment, trimethroprim shows poor biodegradability. The substance is stable towards abiotic factors such as photo-oxidation and heat. A low log p_{ow} value of 0.7 indicates good water solubility and has therefore less relevance for soil pollution (Anonymous, 2007). Therefore no information about its behaviour in soil is documented. In Ternes et al., (2003), ozonation for removing antibiotic residues in waste water has been a successful tool. 5-15 mg per litre ozone was

led into sewage effluent in a pilot sewage treatment plant and proved appropriate elimination of more than 85 % of the trimethroprim and more than 92 % of sulfamethoxacole. Due to its stability towards abiotic factors and biotic factors, the fate of *sulfonamides* in the environment need further investigations.

Among the *nitromidazoles,* metronidazole is effective against anaerobic bacteria and is for example indicated in skin diseases or in intestinal amoebas. Metronidazole is the second frequently used antibiotic after *penicillines*. In this study, it was distributed more than 10,000 kg per year. It is an ingredient in antidiarrhoeal drugs and has often been mentioned among the interview partners at VVU. About 40 % of metronidazole is excreted unchanged with urine and faeces. Metronidazole is weekly adsorbed by soil. In experiments soybean plants and protozoa were very sensitive to metronidazole in concentrations of 0.5 mg/ g soil and metronidazole was harmful towards phytoplankton (Jjemba, 2002). A study with animal slurry tells that the half-life of metronidazole in the soil is between 13-16 days and is biodegraded (Inglerslev and Halling-Sorensen, 2001). In other studies, metronidazole is reported to be non-biodegradable (Jones et al., 2005). Metronidazole is from relevance for further investigations due to its high consumption in the study area and insufficient information.

Azithromycin and erythromycin are considered as *makrolides* in this study. The use of azithromycin is estimated up to 400 kg and 1,500 kg of erythromycin per year. In Ghana, makrolides have been used mostly in hospitals. Erythromycin is not metabolised in the human body and is excreted predominately over faeces. In the environment, it shows a lipophil character with log p_{ow} of 3 and is considered as non-biodegradable. Also Estevez et al. (2005) and Boxall (2004) report persistence in the environment. Sattelberger et al., (2005) in general summarises makrolides as labile as penicillines, which have a half-life of 5-21 days. Anonymous (2007), also cited quick degradation through microorganisms in the soil. Erythromycin has direct toxic effect towards microorganisms in concentrations of mg per litre (Kümmerer, 2004). In Germany detected concentrations range under 0,1 µg per litre and 1,7 µg per litre in surface waters (Anonymous, 2007). Concentrations in sewage sludge

were found from 16 to 36 µg per kilo (Alexy, 2003). In such low concentrations toxic effects can be excluded, but a constant exposition with erythromycin improves the development of resistances in microorganisms. In a STP the degradation is poor and erythromycin carried by effluent can be relevant for aquatic organisms. In a pilot-project in Germany the treatment of sewage effluent with ozone did help to eliminate erythromycin to a large extend (Ternes et al., 2003).

Tetracyclines, for example doxycyclines, were used more than 1,000 kg per year in this study. Considering the application of sludge from animal manure, tetracyclines were regarded potentially relevant for the environment. They have been detected in high concentrations of 100 µg/ kg in soil. Tetracyclines show persistent characteristics (Thiele-Brunn and Peters, 2007; Grote et al., 2007) and are stable towards abiotic factors such as radiation. Acute and sub acute-toxicity from antibiotics applied are minor due to very low detected residues found in the environment (Sattelberger, 1999). But the publisher also emphasises that the main purpose of antibiotics is its effect on microorganisms and points out the resistance development. It is suggested to consider tetracyclines in further studies.

Antibiotics belonging to the group of the *chinolenes* were ciprofloxacin, norfloxacin and ofloxacin. Ciprofloxacin is used in the treatment of several bacterial infections in high quantities of more than 4,000 kg per year. Norfloxacin and ofloxacin have been used in much lower quantities of 267 kg and 130 kg per year. Ciprofloxacin and norfloxacin are adsorbed to the soil particles and show persistent characteristics in the environment (Estevez et al., 2005; Boxall et al., 2004). Less is known about its effects on the environment. DNA/ RNA compounds of *Vibrio fischeri* originated in marine environment were sensitive towards nalidixic acid and norfloxacin (Backhaus and Grimme, 1999). In the environment, ciprofloxacin has been detected in very low concentrations of 0.01-0.1 µg per litre in effluent from STP. Concentrations in the surface water have been much lower. In tests ciprofloxacin was toxic for cyanobacteria at 5 µg per litre (Anonymous, 2007).

Because of bacteria toxicity and its poor degradation, the substance has to be considered as important for further investigations.

Chloramphenicol was used in rather low quantities of 180 kg per year. The substance undergoes a glucoronisation in the human body. Thus, the components become water soluble and can easily be excreted. Further biodegradation through hydrolysis is possible and results in ineffectiveness of the compound (Estevez et al., 2005). *Other* antibiotics such as clindamycin belonging to the *lincosamides,* gentamicin and neomycin from the *aminoglycosides* as well as secnidazole, furazolidone, and thiamphenicol have not been detected or suspected of having further effects in the environment so far. In the gathered data the amounts in those antibiotics were very low.

Antimalarials

Malaria, caused by the parasite *Plasmodium falciparum* carried by the *Anopheles* mosquito, is responsible for more than 40 % of the daily consultations in clinics (GHS, 2005a) and the leading cause in child death under five years of age (WHO, 2006c). Compared with other sub-Saharan countries, Ghana is reporting more malaria cases than its neighbouring countries. The WHO database reports three and a half million cases of malaria in Ghana in 2003. Nigeria, which has to cope with similar environmental conditions being the densest population in Africa with more than 131 million habitants, reports less than 3 million cases of malaria in the same year (WHO, 2007b). Reported cases of malaria in Côte d' Ivoire amount to 400,000 cases in 2001. Concerns about the accuracy of the data are legitimate. One possible explanation for the high rate of malaria is the diagnosis behaviour. Lab diagnosis is exceptions, and over diagnosis and over treatment of malaria follow. Other causes are over usage of antimalarial drugs, which exerts pressure on the effectiveness of these drugs and results in resistances, having happened for example to chloroquine (Knobloch, 2005). But the number of people suffering from malaria is nevertheless increasing, due the resistance to antimalarial drugs, delay in seeking therapy and misuse of drugs (Buabeng et al., 2007). Resistances occur

through increasing use of a single substance (Luellmann et al., 2004) and the incorrect or insufficient intake of antimalarial drugs.

Antimalarial drugs destroy the different stages of the development of the *plasmodium*. Quinine was the well-known antimalarial drug originally from the bark of the *Cinchona officinalis* L. tree (Aktories et al., 2005). Nowadays quinine is still used in the treatment of severe malaria. Chloroquine, invented 1934 in Germany, has chemical similarities with quinine. In 1988, the WHO reported that 190 tons of chloroquine was used in Africa alone (Knobloch, 2005). But resistances from Southeast Asia were brought to Africa. The WHO reports chloroquine resistances of 23 % of the parasite in Ghana (WHO, 2006a). Therefore health policies have changed towards the more effective and expensive artemisinin compounds. Chloroquine was used frequently in the past and is still applied today in rural and urban areas. Remainder from manufacturers and wholesalers could be sold till December 2007 (Yusuf, 2007; Odor, 2007). Chloroquine has been found in various pharmacies and in rural areas as well as in poor suburbs in the metropolis. Artemisinin-based combination therapy (ACT), such as artemisinin derivates with amodiaquine or lumefantrine or sulfadoxine/pyrimethamine, were prescribed throughout in hospitals, and were also available in pharmacies.

One of the effective antimalarial agent currently on the market is extracted from the herb *Artemisia annua* (L.), also known as sweet wormwood, have been used for centuries in Chinese traditional medicine (Vogel, 2005). ACT is recommended by the WHO and is available in health facilities. Different artemisinin derivates can be found in the pharmaceutical markets such as artemether, artesunate and dihydroartemisinin. However, major concerns in the artemisinin based drugs in sub-Saharan countries are the appearance of counterfeit drugs. In South Asian countries counterfeit drugs with less artesunate or no artesunate but with paracetamol are on the market (Newton et al., 2001). For example, pharmaceutical active ingredients of one of these products have been paracetamol and 10 mg artesunate instead of desired 50 mg. Since 2001, the WHO has recommended the use of artemisinin derivates combination therapy, and most of the African countries have made

this change including Ghana. In comparison to chloroquine, artemisinin based drugs present the more expensive choice. This is mainly a problem for the poor, who have to live with less than one Euro a day. High costs for the plant raw material and the expensive drug provide a favourable situation for fake artesunate drugs. Latest reports say that these fake drugs already arrived in Africa (Newton et. al., 2006). Counterfeit dihydroartemisinin and artesunate derivates were reported from Tanzania, labelled as "made in Beijing", whereas counterfeit artesunate in Cameroon was labelled as manufactured in the United States. The arrival of these fake drugs is a warning sign. Corruption within the national purchasing cannot be avoided due to high financial gains, particularly if the distribution of chloroquine shall be prosecuted in Ghana. It will be difficult to tackle the malaria problem without the cheap drug chloroquine available for 2,000- 3,000 Pesewas[5] (around 30 Euro cent) instead of 50,000 Cedis (around 4 Euro). Critics and the manufacturers and wholesalers argue that chloroquine will be brought illegally to Ghana, e.g. from neighbouring countries, to serve the poor people in the country. But there is a necessity for effective management to control malaria in Ghana. The distribution of chloroquine will decline in future but PhaR may remain in the environment by amounts, which might be circulating from uncertain sources in future. The data obtained from hospitals and pharmacies in the Greater Accra region reflect the recommendations in medical treatment from the MoH and the WHO (Fig.9). 2,130 kg of artemisinin based drugs and 2,168 kg of amodiaquine were sold by pharmacies and health centres per year.

[5] Foreign currency one Euro (EUR) = 11,495.55 GHC, 1 Cedi (C)= 100 Pesewas (p) (Devisenkursstatistik, July 2007)

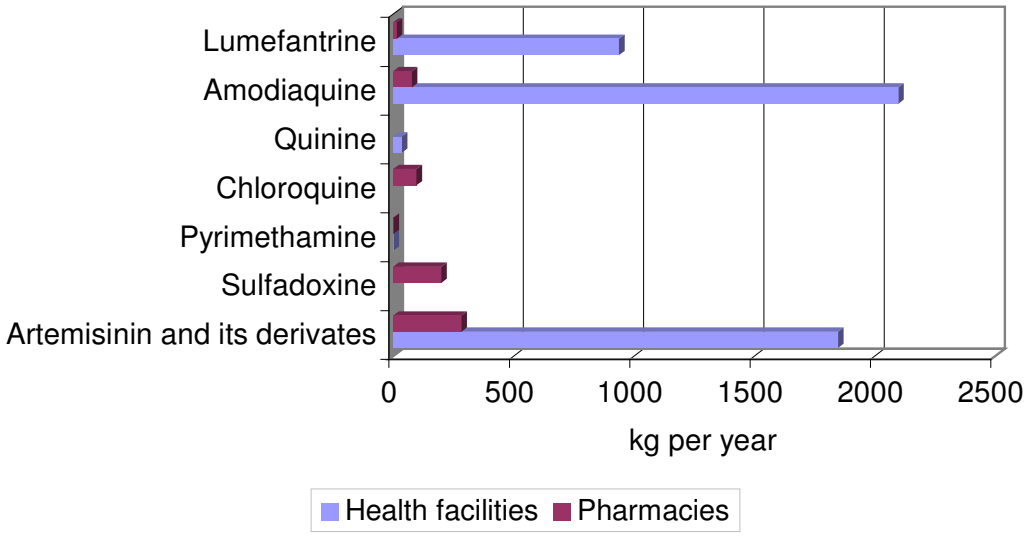

Fig.9: Estimated distribution of antimalarial drugs in the Greater Accra region

Compounds of artemisinin and its derivates are originated from plants and will not be further discussed, as it is expected that these compounds are degraded quickly in the natural environment. The sale of chloroquine in pharmacies has been estimated to 97 kg per year. Pharmacokinetic properties of chloroquine involve the ability of accumulation in the placenta, breast milk, and the retina of humans (WHO, 2006b). Considering the chemical structure of Chloroquine it is likely to be persistent in the environment (Jjemba, 2002). In comparison, chlorinated hydrocarbon such as insecticides including dichlor-diphenyl-trichlorethane (DDT), aldrine, and lindane show a high persistence in the environment and a half-life of 15 years (Collin, 1999). One explanation for their persistence is the presence of chlorine bounds in the molecule, which are difficult for microorganisms to crack (Fangmeier, 2007). No data were found on the fate of chloroquine in the environment, but its octanol/water partition coefficient log p_{ow} of 4.63 indicates a good adsorption to humic particles e.g. on soil. In the administration of chloroquine, overdoses happen often and the substance is accumulated in the body tissue. According to Jjemba (2002), 70 % of chloroquine is excreted unchanged in urine and faeces. In tests the drug chloroquine did reduce population of protozoa at high concentrations and has been toxic to soybean at high concentrations (Jjemba, 2002).

Amodiaquine, a newer drug similar to chloroquine, is fat-soluble, accumulates in the body tissue. It can be found in urine after months after its application (WHO, 2006b). Information about amodiaquine after its excretion is not available.

Lumefantrine (benflumetol) is an effective drug, at the moment used in remarkable quantities (Fig. 9) of 950 kg, combined with artemether. Little else is known about lumefantrine. The compound is fat-soluble and its three chlorinated functional groups may indicate persistence in the environment. In databases nothing is reported about its fate and behaviour in the environment.

Sulfadoxine, belonging to the antibiotic class *sulfonamides,* has a low log p_{ow} of 0.7, indicating hydrophilic behaviour. 230 kg per year are sold in the Greater Accra region. No data about its fate and behaviour can be found. Pyrimethamine is used in combination with sulfadoxine for the prevention and treatment of malaria. Quantities are estimated to about 3 kg per year in the Greater Accra region. With its log p_{ow} of 2.69, it shows moderate adsorption onto organic matter. In ecotoxicological tests, only very high concentrations of 25 mg pyrimethamine per litre showed inhibition of folic acid synthesis in marine bacteria *Vibrio fischeri* (Backhaus and Grimme, 1999). Both substances are considered among the antibiotic drugs.

Antihelminthics

Billions of people in the whole world are affected (Aktories et al., 2005) by several pathogenic protozoa in the intestine, such as hookworms *Ancyclostoma duodenale*, tapeworms *Cestodes*, threadworms *Enterobius vermicularis*, whipworms and roundworms *Ascaris lumbricoides*. Inadequate or non-existing sewage disposal, unsafe water supply, tropical climate, poor hygiene, and walking bare-footed on the soil, from which the worms or their eggs can penetrate the skin, are contributing factors (MoH, 2004b). In the metropolis of Accra advertising panels seen in Fig.10 demonstrate how common worm infestations may be.

Fig.10: Wormplex 400- Advertising for antihelminthics in Accra

Major antihelminthic drugs consumed in this study investigated are albendazole and mebendazole. Mebendazole is effective against hookworms, whipworms, roundworms, trichinas and threadworms. The substance is inhibiting the absorption of glucose in the worm cells. Parasites are dying due to maldigestion. Albendazole can be used as an alternative to mebendazole. Thiabendazole and praziquantel are other recommended substances (MoH, 2004b).

The sales of antihelminthics are moderate. The most common used drugs with a consumption of 86 kg mebendazole and 22 kg albendazole per year in hospitals and health centres. Pharmacies distribute another 67.5 kg mebendazole and 77 kg albendazole in the study area. Other antihelminthics were thiabendazole with 12 kg, praziquantel with 10.5 kg and ivermectin with only 1 kg per year.

Data about the fate of mebendazole and albendazole in the environment is rare. Metabolites from both substances are excreted over the renal and biliary system (Schneider und Richling, 2007). However, ivermectin and thiabendazole are often found in veterinary medicine. Ivermectin appears mostly in faeces,

whereas only 1 % is excreted with urine (Drug Bank, 2007). In Halley et al., (1993), it is to find that ivermectin is immobile in the soil and likely to bound to organic matter. On the surface of the soil, it is degraded aerobically in less bioactive compounds in less than a day. In soil/faeces mixtures, the half-life is about 14 days. Considering the European chemical substances information system, thiabendazole is toxic for aquatic organisms and belongs to hazardous waste. Metabolised residues appear in urine completely as glucuronide or sulphate conjugates (Drug Bank, 2007). For further studies, albendazole and mebendazole are of interest due to the little information available and the possibility of harming the soil fauna through the application of contaminated human waste as a fertiliser.

Antifungals

Antifungal drugs can be applied orally or dermal via ointments for the skin (Schneider and Richling, 2007). They are used for the treatment of skin diseases such as *candida spp*. Broadband antifungal drugs include fluconacole or ketoconazole. Data obtained in the study shows that 30 kg of clotrimazole drugs and 1.2 kg of ointments with miconazole or isoconazole in minor amounts were sold per year. Clotrimazole with a log p_{ow} of 6.2 indicates a strong adsorption to the soil. In laboratory tests, clotrimazole was expected as non-biodegradable with a half-life of more than 60 days. Clotrimazole has been detected in the aquatic environment in low concentrations (Peschka et al., 2007). For further investigations the occurrence and fate of residues of fungicides are of interest due to their possible effects on fungi in the soil.

Retroviral therapy

The HIV/AIDS prevalence in adults is between 1.9 and 5 %. About 210,000 to 560,000 people from 0-49 years live with HIV/AIDS. Figures from the WHO show that the use of retroviral drugs is very low and that there is a need for more antiretroviral drugs. The reported number of people between 0-49 years receiving antiretroviral therapies in 2005 was 3,584. The estimated number of

people needing antiretroviral therapy was 61,000. Only 5.8 % of the patients in need receive antiretroviral therapy (WHO and UNAIDS, 2005). The first line drug regimen is zidovudine+ lamivudine+ nevirapine or efarivez. The second line treatment could be abacavir+ didanosine+ nelfinavir, or other lines are suggested. The STG consider using antiretroviral therapy as a prophylaxis within 24-48 hours if exposure to the virus is suspected and includes the first drug regimen for 28 days. Drugs used in HIV/AIDS are exclusively available in certain hospitals. Pharmacies and hospitals visited during the study neglected antiviral drugs. Dispensed drugs from the health centres for HIV/AIDS must be too low to have potential effects in the environment so far.

3.1.3 Antidiabetic drugs

Non-insulin-dependent diabetes mellitus is more prevalent in developed countries, but it is expected that sub-Saharan Africa will catch up in the next thirty years due to increasing ageing, urbanization and physical inactivity (Wild et al., 2004). The number of people living with diabetes in Ghana was estimated at 300,000 in 2000 and will grow in future (WHO, 2008). Antidiabetic drugs are used mainly for non-insulin-dependent diabetes mellitus. Metformin an oral drug comes to 14,640 kg annually from the hospitals and another 900 kg from the pharmacies. Each tablet contains 500 mg. A patient with non-insulin-dependent diabetes mellitus requires 2000-2500 mg metformin daily; therefore the high quantities are justified. Other drugs were glibenclamide with 126 kg tolbutylamide with 11 kg per year and minor amounts of glimepride. Metformin has been used for more than 40 years in Germany and there is rising concern about its fate in the environment. The substance is not metabolised in the human body but microbial activity transform the substance to guanylurea, which can be detected in the aquatic environment. Properties of guanylurea have not been investigated so far (Trautwein and Kümmerer, 2008).

3.1.4 Cardiovascular drugs

Hypertension is the dominating condition among the CVD. Although, it is more likely to be found in industrialised countries, its position in Table 1 gives evidence that lifestyle diseases are emerging in Ghana. Studies have shown (Agyemang, 2006; Pobee et al., 1977; Addo et al., 2006) that high blood pressure is increasing among the urban and rural populations in Ghana. Hypertension is caused by the changing lifestyle in urban areas, which entails an increase in industrialised food, smoking or lack of exercise. Another risk factor for CVD is non-insulin-dependent diabetes mellitus, smoking or hypercholesterinanaemia.

In industrialised countries, CVD are the major cause for death. Heart attack due to clogging in the vessels, stroke, and renal failure can follow. Abu-Bakare et al., (1986), sees a correlation between malnutrition in childhood and the appearance of non-dependent insulin resistance, also called tropical diabetes in adults. A study carried out by Brawley (2003), highlights that in rats a dietary restriction of protein during pregnancy results in hypertension in the offspring. This would not necessarily attribute to lifestyle changes but to undernutrition, which is common in Ghana.

Often studies are financially supported by local pharmaceutical companies, which can influence the conclusion and reduce the reliability of objective results. One study sees the non-compliance with the hypertension problem with unaffordable drug prices, rather than investigate the condition as being due to its causes and solutions (Buabeng et al., 2004).

In the data obtained from the hospitals CVD were ranked in second and third place. This indicates a very high consumption of drugs in CVD. It is not clear, whether pharmaceutical companies trigger this development though special offers, and if the majority of patients have a high affinity to use drugs. However, lifestyle diseases in developing countries are emerging (Wild et al., 2004) and it is to be assumed that hypertension, which is apparent in Ghana, will increase in urban areas that on the other which will evoke the need of appropriate drugs.

In hypertension, non-pharmacological treatment includes the reduction in body weight, a decrease in alcohol consumption, quitting smoking and reducing the salt intake in the diet. Pharmacological treatment compromises diuretics,

angiotensin converting enzymes (ACE-inhibitors), beta-blockers and calcium antagonists (Luellmann et al., 2004). Popular drugs and suggested drugs in the STG 2004 are atenolol (beta-blockers), lisonopril (ACE-inhibitors) and nifedipine a calcium channel blocker. Furthermore, propranolol and amlodipine besylate are common drugs. Estimations in this study come to the conclusion that methyldopa, nifedipine and atenolol were the major drugs with more than 1000 kg being sold of each per year (Fig.11).

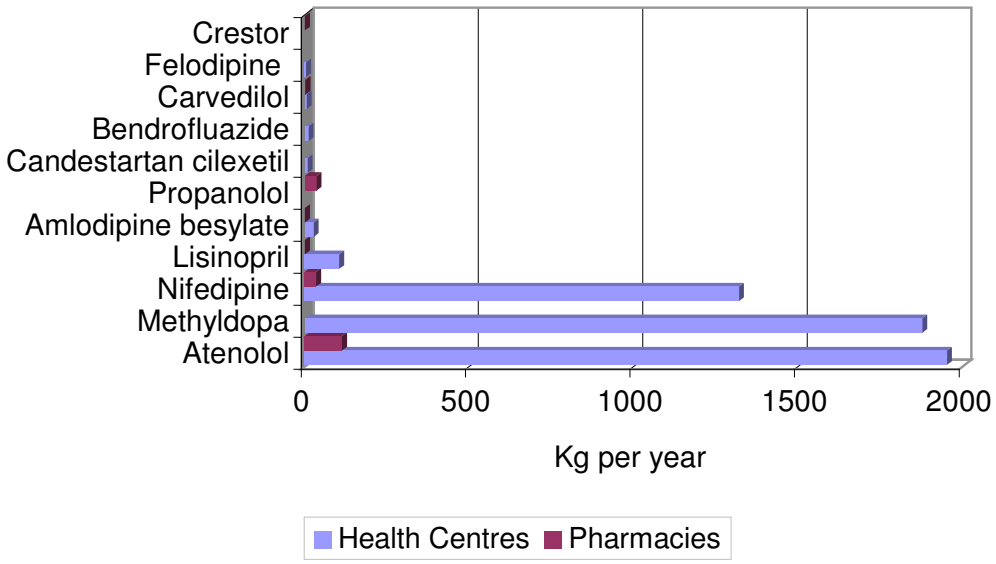

Fig.11: Distribution of cardiovascular drugs

Dataset by the European Chemical Bureau reports the biodegradability of nifedipine at 10-60 % after 28 days in activated sludge treatment (ECB, 2000).
Methyldopa has been declared as non-biodegradable in sewage sludge (Halling-Sorensen et al., 1998). With its low log $_{pow}$ (octanol/water partition coefficient) of -1.79 it is likely to be detected in the aquatic ecosystems.
Atenolol has been discussed in the paper by Anonymous (2007). The ß-blocker is hydrophilic and is predominately excreted with urine. Its low log $p_{ow\ of}$ 0.16 indicates that the sorption into soil is low and has therefore more relevance in waterbodies. In Germany, it was detected in a concentration of 0.01 and 0.1 µg per litre of in surface waters. There are no data about atenolol in soil (Anonymous, 2007).

For the other substances little information on their environmental fate and behaviour was found. Information found on atenolol, nifedipine and methyldopa were insufficient and further investigations are necessary.

3.1.5 Drugs used in Diarrhoea

Diarrhoea is the frequent passing of loose, watery stools three times a day or more. It is a symptom caused mainly by viruses, bacteria or protozoa. Children under five years are the most vulnerable group. Poor personal hygiene, food contamination and the inadequacy of water and sanitation facilities cause infectious diseases, where diarrhoea results (MoH, 2004b). Antidiarrhoeal drugs are used to shorten the passage time in the bowel. Loperamide is in use to normalise the peristalsis. Other substances in use are activated charcoal or antibiotics. Important in diarrhoeal diseases is the replenishment of lost fluids, minerals and sugar. Here oral rehydration solutions are the most given treatment in diarrhoea. Considering the STG and the rational drug use, antibiotics are given in severe diarrhoea which is related to bacterial infections and goes together with fever and blood in the stool (MoH, 2004b). Oral rehydration solutions had no relevance for this study. The most used substance loperamide was widely available and used in urban and in semi-urban and rural areas. Loperamide comes to 1.4 kg per year. It is metabolised almost completely and appears then in the faeces (Schneider and Richling, 2007). In databases less is reported about the fate of metabolites fate in the environment. Loperamide has not been found in the data in hospitals and will not be further discussed.

Other medicinal preparations, found in diarrhoea were the combinations of antibiotics (Fig.12). It contains metronidazole, which is effective against anaerobic bacteria, and furazolidone, an antiprotozoal drug. In an evaluation of promotion campaigns in Pakistan the product Metrolex-F, distributed by an Indian company, claimed in the slogan „magic combination in all kinds of diarrhoea", which is exaggerated as the product shows only minor advantages in the treatment of diarrhoea (Rohra et al., 2006). Active pharmaceutical substances are considered in the anti-infective drugs; nevertheless, this

appearance of those products shows an abuse of antibiotics, waste of resources and increase of drug entries into the environment.

Fig.12: Two antibiotics in one-example for irresponsible antibiotic use

3.1.6 Contraceptives and other hormones

Contraceptives have their function in inhibiting pregnancy. They can be taken *naturally* with the calendar method, *mechanically* e.g. with barrier methods such as condoms, *chemically* with spermicides or *hormonal* via oral contraceptives or injections or as implants under the skin (Hatcher et al., 1997). Among the oral contraceptives 17 α-ethinylestradiol is the most applied active ingredient in Germany (Mutschler, 1996). Ethinylestradiol came into discredit through having further effects in the environment through its endocrine activity in the feminisation of male fish (Larsson et al., 2000; Purdom et al., 1994). Hormones can have their effects in much smaller quantities as other therapeutic classes; therefore hormonal contraceptives have been considered in this study. The total consumption of ethinylestradiol in Germany has been 50 kg from 31,000 t of the total consumed drugs per year and has therefore its importance (SRU, 2007).

Studies in sub-Saharan countries show that contraceptive use relies mainly on traditional methods. This includes the practices of the calendar method and withdrawal (Anonymous, 1993). The effectiveness of these methods is considered lower than modern contraceptives, which include condoms, oral contraceptives, intertaurine devices (IUD), injections, implants, spermicides and

diaphragms. In Ghana, the majority of contraceptives are sold in the pharmacies such as hormonal pills or spermicides. Other methods are available in the clinical setting of a health centre, which offers contraceptive methods such as implants, IUDs, or injections. The data collected in this study is based on the information from 18 health facilities including family-planning settings and retail pharmacies. The figures were extrapolated over a year with 725 health facilities in the Greater Accra region.

Exact figures can be taken from the appendix. Considering the data gained from this study around 40,000 women relied on modern contraceptives. If it was assumed that 500,000 women in reproductive age from 3 million people were living in the Greater Accra region about 8 % relied on modern contraceptives. Excluded were methods such as condoms, IUD, sterilisation and natural methods. As in Fig.13 illustrated spermicides, oral contraceptives, and emergency contraceptives made the biggest proportion of modern contraceptives. In Ghana, national estimates from the Demographic Health Survey indicate that these methods have been used in 1993 by 10 % of women between 15-49 years (Anonymous, 1993). The estimated 8 % indicates that the number of women using modern contraceptives has not changed significantly.

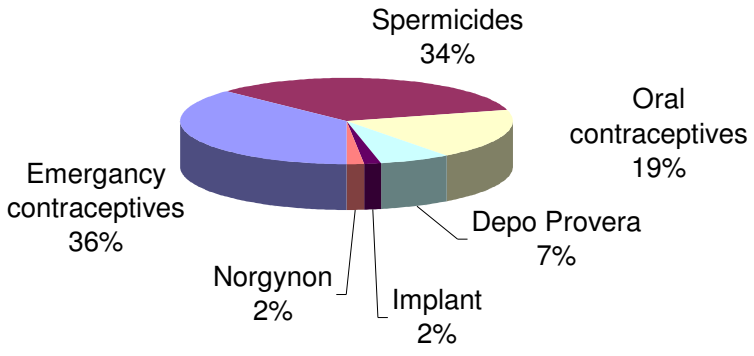

Fig.13: Distribution of modern contraceptives estimated per year among 40,000 women

In Germany, no quantitative data about hormonal contraceptive methods exist. The figures in Germany estimate the consumption in women of a reproductive

age and assume that 50 % of all would use oral contraceptives 21 days in 12 months with the common doses of 0.02-0.05 mg ethinylestradiol and 0.1-0.25 mg levonorgestrel (Abbes and Kratz, 1999). Using this example for the Greater Accra region, which has about 3 million habitants, of which 1.5 millions were female and 500,000 were at a reproductive age 500 g ethinylestradiol per year would be used. The data collection in the health facilities shows that the use of modern contraceptives is well practised. In this study following the WHO standard method 0.07 kg (70 g) ethinylestradiol per year was estimated. In publications ethinylestradiol is discussed about its fate in the aquatic ecosystems. A conventional sewage treatment plant is not able to remove the synthetic hormones (Solomon, 2005). Little is known about its fate in soil.

Another common form of contraceptives in Ghana is the product postinor2 ® with its ingredient levonorgestrel working as an *emergency contraceptive*. One package consists of two pills with 0.75 mg. In this study the amounts of levonorgestrel came to 260 g per year in the Greater Accra region.

Implants include six plastic capsules, which are placed under the skin of the woman (e.g. upper arm). Each capsule contains 36 mg levonorgestrel, similar to natural hormone and is released very slowly but can last for five years (Hatcher et al., 1997). The use of implants was estimated to be 1450 capsules per year in the Greater Accra region. Little is known about the fate and behaviour of levonorgestrel in the environment.

Spermicides belong to barrier methods and enter the body over the skin. They contain nonoxynol-9 or menfegol belonging to the steroid hormones and eventually reach the environment exclusively in the grey water. A transformation by the kidneys in the body does not follow. Therefore, the substance can reach the environment unchanged e.g. via grey water. Popular spermicides in Ghana were Today®, Kamal® or Sapoon[6]. Their annual usage comes to 3 kg nonoxynol-9 predominately in urban and semi-urban areas. About 4 mg nonoxynol-9 is in each tablet. The spermicide nonoxynol-9 is only cited in one

[6] Contains menfegol instead of nonoxynol-9 but belongs to the spermicides

study about its endocrine activity (Bourinbaiar, 1997) and is therefore regarded as a hormonal contraceptive in this study. Nothing about its fate or occurrence in the environment has been reported.
Depotmedroxyprogesteron (medroxyprogestone acetate), better known as Depo Provera®, consists of progeston and has to be injected every three months. *Injections* with medroxyprogesterone (150 mg/ ml) are estimated sold 96,666 ampoules with 14 kg per year. Norgynon another injection which active ingredients are 5 mg estradiol and 50 mg norhisterone comes to 3 g ethinylestradiol per year. Little is reported about norhisterone and medroxyprogestone after its administration in the environment.

Overall, the figures indicate that modern contraceptives are used and known about. Nevertheless, the estimation of 8 % indicates that the consumption of modern contraceptives is not outstanding. Hormonal contraceptives are widely used in developed countries. The use of modern contraceptives was low and dependent on sceptics about the effectiveness and fear concerning side effects (Addai, 1999). Relevant substances are medroxyprogestone, nonoxynol-9, levonorgestrel and ethinylestradiol, but it is to be assumed that the low amounts are too low to show further effects in the environment.

3.2 Prescription and drug-use habits

Many developing countries spend up to 40 % of their total health-care budget on drugs. A large proportion of drugs are wasted through irrational prescription habits. At the same time, Ghana is rather suffering more from shortages in pharmaceutical supply. Despite this fact, prescribing several drugs that are sometimes unnecessary is the practice. A study from 2002, found out that 3.4 drugs per patient were prescribed (WHO, 2002). Usually antimalarials, analgesics, antibiotics, antihaematinics and antihelminthics were among them. Comparing other developing countries the average of prescribed pharmaceuticals per patient is 1.9. For instance, 2.0 in Kenya, and 3.1 in the western region of Sierra Leone (Bosu and Adjej-Ofori, 2000) are prescribed.

Antibiotics, as discussed earlier, are used in large quantities. Due to several pathogens causing infectious diseases and are adapted to the climatic and environmental conditions, the need for antibiotics is justified. But an excessive antibiotic use is expensive, wasteful and risky because of developing antibiotic resistances, which is a growing problem worldwide.

In Ghana, several antibiotics were sold over-the-counter, which means they are available without prescription and can be taken inappropriately, due to lack of money or the awareness to take the correct dosage (Buabeng et al., 2007).

Lack of diagnostic facilities (Bosu and Adjej-Ofori, 2000) intensifies the difficulty to identify the causes for the diseases. Due to this one to three antibiotics were prescribed at a time. Antibiotics were prescribed for malaria, upper-respiratory infections (URI), soft-tissue infections, injuries, diarrhoeal diseases and skin diseases in over 70 % of patients. Using several types of antibiotics enlarges the spectrum of the bacteria, which may cause the infection. A broad-spectrum antibiotic for aerobic bacteria, and another for anaerobic bacteria prescribed is an example (Schäfer, 2007).

The usage of antibiotics in URI and malaria is inappropriate due to the fact that mostly viruses cause URI and do not require any antibiotics (MoH, 2004b). Furthermore, with regards to diagnosing behaviour an antibiotic is given too easily as in cases with malaria (Knobloch, 2005), or diarrhoea and colds, which are caused by viral infection.

Patients' own perceptions encourage the prescription habit too. The reputation of being a good doctor largely depends on the prescription of drugs. A doctor who is not prescribing medicine is not perceived as a good doctor (WHO, 2002; Young, 2000).

This prescription pattern is related to the training of the medical staff. The more training they had received, the fewer drugs they prescribed. Prescribes in general have a lack of objective therapeutic information and are influenced by commercially oriented publications. Twumasi (2005) argues that workers in this health institution have recently moved from rural to urban settings and are used to receiving instructions from the traditional elder. Individual decisions were not expected. Now the individual confronts with a work situation, which comprises commercial information, education and treatment guidelines.

Inappropriate drug use was also related to the knowledge of patients, of whom less than half (42.1 %) had adequate knowledge of how to take the drugs in the 2002 survey (WHO, 2002). Drugs obtained from pharmacies or clinics were used more accurately than from chemical sellers[7] or other sources, which can include leftover medicine from home or from friends (Buabeng et al., 2007). Any medicine is accepted from a trustworthy source, but the more educated this source is the more knowledge the patient will have on how to take the drugs and will receive less drugs.

Another trigger of excessive use in drugs may be the "Cash and Carry" system. Patients had to pay directly for health service and drugs. Very poor and vulnerable persons were excluded from this rule. The cost recovery of drugs enables the health institution to buy new drugs. This system will now be replaced by a national health insurance scheme (Yusuf, 2007). Critics had argued that the old system made it more attractive to sell several and perhaps inappropriate drugs, in order to gain more money (Aseno-Okyere et al., 1999). However, there are several factors, which can lead to more inputs of pharmaceuticals than necessary that will eventually enter the environment via excrement or drugs disposed by the patients.

3.3 Traditional African Medicine

Every culture has its own way to explain and to deal with illness. For centuries people in Africa have relied on traditional healers and their practices (Young, 2000). Since the arrival of scientific medicine[8] the sick person is offered two alternatives for medical help. Ghana's scientific medical service dates back to the colonisation by Britain in 1844. Time after time missions in the country brought medical officers to take care of their own personnel. Later dispensaries were established and influenced the areas. By 1878 medical work started in Accra and spread slowly to other parts, mainly to the large towns

[7] The difference between a chemical seller and a pharmacy is that there is no pharmacist in charge.

[8] The term was originally used to explain the rational causes for the emerging of diseases while African traditional medicine involves supernatural causes. Nowadays it means the treatment in hospital by doctors, nurses and pharmacists rather than the attendance of an herbalist or a diviner.

(Twumasi, 2005). The high number of health centres and pharmacies located in the Greater Accra region clearly reflects the situation. This development has pushed back traditional medicine. African medicine was attacked as "black magic" with no scientific proof efficiency, which led to the use of Western medicine being encouraged.

Independence, cultural identity and practical reasons led traditional African medicine to re-emerge. Especially in rural areas, many people still rely on traditional practitioners for all their health needs (Young, 2000; Kwadwo Aseno Okyere, 1995). In 1978 the WHO made a great step forward by recognising the role of traditional medicine and encouraging research into these therapies which usually consists of herbal remedies. Critics argue that this reduces African medicine to only herbal remedies and forgets the spiritual context of healing.
However, in Ghana the Psychic and Traditional Healer Association were established and integrated Western medicine with traditional medicine (Young, 2000). Also the Ministry of Health established a unit in charge of herbal medicine (Kwadwo Aseno Okyere, 1995).

Traditional practitioners include herbalists, midwives, diviners *Juju* and other spirit mediums. In this study only herbal preparations should be discussed, which are used for treatment and prevention of diseases. Preparations differ from one practitioner or family to the next and dosages are not predictable. Parts of plants, leaves, roots, and the bark of the trees can be cooked, ground, dried or chewed. Besides oral intake, application follows over the skin (creams, wet packs) or anal. Knowledge is gained through the family or messages received via spiritual way. Some spiritual aspects are still in practice during the process of collecting certain plants, such as moving backwards and not facing the plant directly. Otherwise it is said that the application has no effects (comment by the herbalist, July 2007). The herbs are used for various kinds of diseases such as dandelion *Taraxum officinale* in hypertension, *Moringa oleifera Lam.*, or neem *Azardirchata indica Adr. Juss*. Mixtures of leaves are used as antipyretics, contraceptives or for stomach aches and skin rashes. Bitter leaf *Veronica amygdale* and leaves of the neem tree and paw paw

Carica papaya (L.) is used as antimalarials or to prevent disease. Furthermore, the skin of pineapple *Ananas comosus (L.) Merr.* and sugar cane *Saccharum officinarum (*L.) as well as bitter leaf *Vernonia amygdalia* were used in fever (Fig.14).

Fig.14: Bitter Leaf *Veronica amygdale*

The herbalists from the traditional herbalist association of the Northern Sector of Ghaftram in Dodowa and Kwadwo Aseno-Okyere believe that herbal medicine will play a major role in health care in future (1995). Experiences and recipes are shared and discussed during their meetings. Some Traditional medicine can also be obtained at the markets in Accra. Roots, skins and seeds can be bought for various symptoms like anaemia and skin problems, and for increasing virility in men. It is assumed that natural remedies have a low relevance in the ecosystem. Degradation or the adjustment of active pharmaceutical substances is expected because of its natural origin (SRU, 2007). Due to that reason herbal medicine is not discussed in this study but has an important position in the health sector.

3.4 Estimated drug use pattern in rural areas

For the estimation of drug use in rural areas the four locations of Adomrobe, Malejor, Dodowa and Bawaleshi were visited. Most of the villages were close to a main road "Dodowa -Road" and in the surrounding of the VVU (Fig. 15).

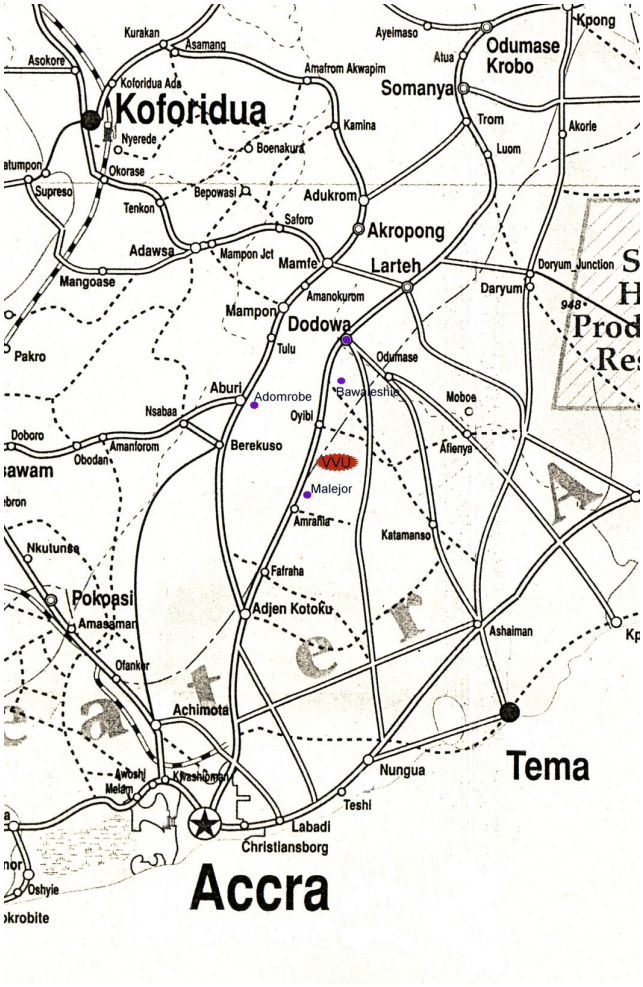

Fig.15: Location of the villages around Valley View University

All the locations are within 20 km from the VVU, and the capital Accra is about an hour's drive. The nearest health facilities in this region are the Dodowa Health Centre, pharmacies in Dodowa and on the main roads to Accra. Primary health care[9] or a small supply from private people can be found. Villages and other settlements around the VVU are often close to the main road, which leads

[9] Trained person for giving injections and over-the-counter drugs. Refers to specialist if further treatment options are needed.

to Accra in the south or to Dodowa in the north. Other villages can be reached via rough roads further away. This favoured settling near to the main road. Local people said that this resulted in the building of the Akosombo dam in the 60s, after the government failed to re-establish villages. However, the main road offers good access to health facilities.

Translation in all the villages was of great benefit, although the majority spoke English. The ethnicities of the people were Ga or Akan, which means the people having Ga and Twi as their native language. It has to be assumed that some information got lost during the translation process.

Two villages consist of 200 and more members, while in Bawaleshi and Dodowa a township consists of up to 2,000 and 5,000 members, respectively. Villages around seem to grow equal to the expansion of the VVU, and new houses and settlements are mushrooming from existing communities. Residents are mainly involved in agriculture or at the construction sites. Interviewees were selected by choosing the appropriate age and sex.

In the beginning women and later men were asked to grab a handful of peanuts and put them into the months and describe the common diseases that they have had in their family. Later, the discussion followed. The majority of the women and men placed the peanuts during and at the beginning of the rainy season (Fig.16). Hardly any peanuts were placed between rainy and dry season.

Fig.16: Example for a distribution of the diseases in the annual cycle

Generally most of the participants claimed to feel healthy. Deficiencies in iron or and vitamins have been reported. In all groups malaria affected their family and themselves most. The rainy season was associated with malaria, diarrhoea and upper-respiratory infections. The dry season was associated with dry skin, nose bleeding and coughing. Skin rashes and boils were mentioned in most of the communities. Seasonal dynamic of the drug residues should be considered in further studies. Some problems such as back pain were related to work like working on the farm or on the construction site. Herbal medicine is also used and sometimes even preferred for prevention and in the treatment of diseases. In the communities the term cholera was used to describe gastroenteritis and was associated with the consumption of mangos *Mangifera indica* (L.) contaminated by flies. Real cholera disease was absent. Children were affected most with diarrhoea, measles and worm infestations.

In the group discussions only elderly people were affected by stroke and diabetes. In Germany and in other industrialised countries these diseases are often associated with ageing, poor diet, smoking or over-nutrition. In the daily jargon lifestyle diseases describe the causes very well. Nowadays, in developing countries lifestyle diseases seem to emerge. One example of this is non-insulin-dependent diabetes, once described as absent in West African villages (Werft et al., 1987). Cardiovascular diseases (CVD) appear in rural and urban areas (Addo et al., 2006). Hypertension is a leading cause for CVD in rural Ga area and nearly eight times more frequent than 30 years ago. Rural areas have generally a lower prevalence for hypertension than in urban settings (Addo et al., 2006; Agyemang, 2006; Pobee et al., 1977). The adoption of modern lifestyles, e.g. changing of alimentation or declining physical activity by the use of automobile transportation, are some causes that explain the transformation in the rural areas. In both of the studies, the awareness of the health condition hypertension was low. Poor health-service attendance and illiteracy are seen as a reason for this.

In the group discussions, it was anticipated that these diseases would appear in urban areas more frequently than in rural areas. Nevertheless, the conclusion can be drawn that the price of the drugs and the accessibility is the major

barrier for its low or no consumption of antidiabetic and CVD drugs. A lower price or a better accessibility would probably mislead the patients to use more pills rather than changing the diet or reducing body weight. HIV/AIDS were never mentioned in a discussion. Only one community described a "wind" that takes the people away. Probably there was no awareness for a possible infection and the group discussion makes it difficult to talk about it due to stigmatism.

Concerning the family planning in all of the four villages the women desired to have four or more children. Older women had up to six children. The average woman in the discussion had 3.4 children. None of the women mentioned modern contraceptives. Abstinence, calendar method or herbals are the practised methods. Everybody claimed to know about modern contraceptives but would not use them. The low rate or in this case the denying of modern contraceptives due to scepticism about the effectiveness and fear about side effects, for example becoming infertile. A man explained in the group discussions that family planning is a woman's business.
In a study by Geelhoed et al. (2002) men using contraceptives reported using condoms in 90 % of the cases, while women hardly mentioned this method. The study comes to the conclusion that contraceptives are seen as a method for achieving a small family and for spacing out children, rather than to avoid pregnancies or sexually transmitted diseases.

The participants in the group discussions claim that pharmaceuticals in general are expensive and they could not afford drugs, e.g. in diabetes. Affordability is the problem rather than accessibility.

The overall drug use in rural areas seems moderate. Due to difficulties in access and affordability, traditional medicine is preferred. It was not common that residents took drugs in CVD, non-insulin-dependent diabetes mellitus or hormonal contraceptives due to lack of money and negative perception towards these drugs. Neither CVD, nor non-insulin-dependent diabetes is perceived not as a major health problem. Major health problems perceived in the settlements were malaria. Dietary supplements were taken and participants were probably

aware about iron and vitamin deficiencies. If drugs may be consumed seasonal variations have to be considered. Infectious diseases and malaria were associated with the rainy season.

The usage of pharmaceutical products can be regarded as lower than in the suburbs and in the metropolis of Accra, but can increase if the purchase power and availability increase.

Pharmacies are rare in the villages. In accordance to the health directory around 10 pharmacies provide service within the Greater Accra region. Despite the pharmacies some primary health care were available in the settlements which can dispense over-the-counter drugs and trained staff able to dispense drugs, give injections or to transfer the patient to an appropriate health facility In the study area two village pharmacies and a NGO with a running health programme were visited and staff were interviewed. Drug use correlates strongly to drug accessibility. The range of therapeutic groups covers painkillers, antimalarials, antibiotics and dietary supplements. Some offered antacids, antidiarrhoeals, antihelminthics, oral contraceptives and condoms. Drug supply in the villages is dependent on bids, donations and the purchases of retailers. In the villages as well as in the pharmacies drug supply fluctuates strongly over time and in the pharmacies itself. The compositions of the possible PhaR in wastewater definitely vary strongly depending on the drugs administrated.

3.5 Estimated drug use at Valley View University

Around 700 students and employees were on campus, when the interviews took place. From aimed 100 students and workers 94 people volunteered for the interviews. Of the 51 were male and 43 were female. About 75 % of the participants were students who attended summer school. The other participants belonged to staff and faculty members. The age of the participants ranged from 18 to 54 years and were asked on the campus for the interviews. At the beginning the participants were asked if and which diseases they had during the last six months. Five persons responded not to have had any diseases. Multiple

answers in the interview were possible and desired were applicable. From 191 responses the following pattern in Fig.17 was achieved.

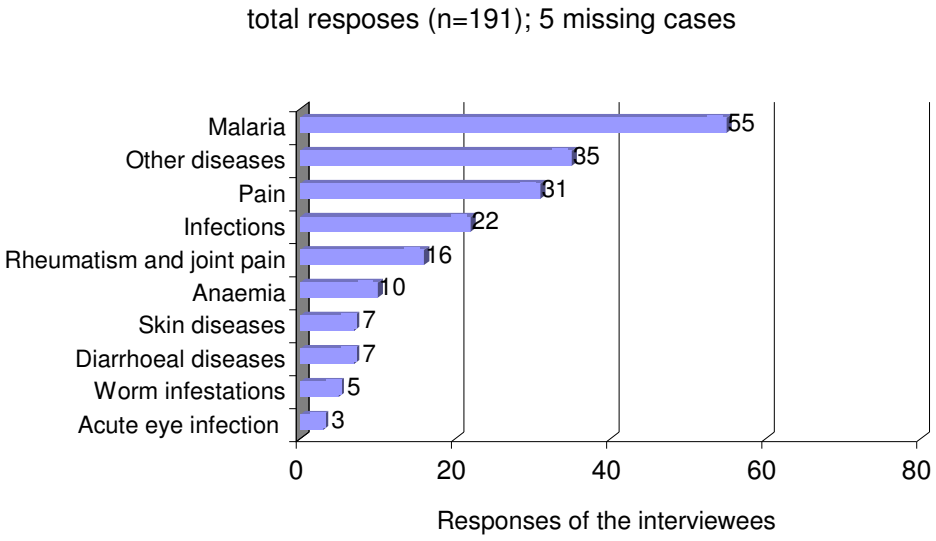

Fig.17: Distribution of the diseases

Malaria as usual exceeded all the diseases. More than half of the interviewed persons (n=55) mentioned to have suffered from malaria within the past six months. None of the interviewed persons mentioned hypertension, other cardiovascular diseases, non-insulin-dependent diabetes or pregnancy-related complications. Upper respiratory tract and urogenital tract infections followed with almost 12 % (n=22) of all the cases. Furthermore rheumatism, which describes joint and back pain, acute eye disorders, skin diseases, anaemia, diarrhoea and worm manifestations were mentioned. All other diseases can be found in minor proportions and are gathered among "other diseases". The term pain relates to abdominal pain or headache. This condition itself was used as a variable.

Distribution of the used therapeutic groups

Questions about the last used and current drug have been asked. Many of the respondents did not know the names of the drugs they had taken. More useful was the information when the interviewers could show the drugs and their packages. Unfortunately answers like "I went to the nurse and received some tablets" or "I have been treated in the hospitals" were more frequent. After all

still many of the respondents were able to know exactly what they had used and are using at the moment. Among the respondents, painkillers make the greatest proportion of drugs followed by antimalarials, dietary supplements and herbal medicine and are listed in Table 5.

Table 5. Distribution of the used therapeutic groups (n=191) multiple responses were possible

Therapeutic groups	**n= 191 (100 %)**
Analgesics	54 (24 %)
Antimalarials	45 (20 %)
Other substances	34 (15 %)
Dietary supplements	27 (12%)
Herbal medicine	22 (9 %)
Antibiotics	15 (6 %)
Antifungals	7 (3 %)
Antihistamines	8 (3 %)
Antidiarrhoeals	5 (2 %)
Antitussivas	5 (2%)
Antihelminthics	5 (2 %)
Laxatives	3 (1%)
Contraceptives	3 (1%)

Analgesics

Among the painkillers diclofenac was used 9.5 % (n=7), acetylsalicylic acid 12.2 % (n=9) and ibuprofen with 18.9 % (n=14) of 74 total responses. Paracetamol was the most often taken painkiller with 55.4 % (n=41) of 74 total responses in 50 valid cases see in Fig.18. Multiple responses were possible. Combination of drugs such as paracetamol plus ephedrine or caffeine plus paracetamol and other combinations refer to the appropriate substances. Other painkillers such as naproxen or buscopan were used to a less extent and make up only 4.1 % (n=3) of the total responses.

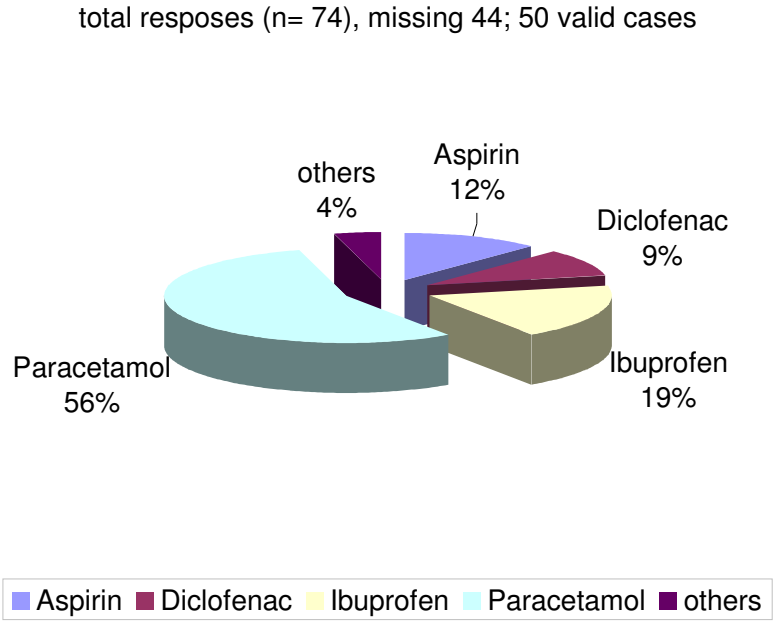

Fig.18: Distribution of the painkillers (total responses=74)

Antimalarials

Treatment options in malaria are converting from chloroquine away to artemisinin-based drugs. Artemisinin and its derivates are favoured at VVU. Education and also affordability are factors for this high proportion in artemisinin derivates use. However, the WHO and the STG 2004 refers to combine artesunate with amodiaquine or with lumefantrine to prevent resistances by the *plasmodium* parasite. Chloroquine was the least choice among the interviewed people at the VVU with 4 % (n=2). Sulfadoxine/pyrimethamine interestingly came to 15 % (n=7) and was also mentioned as the first choice before artemisinin compounds. Two interviewed persons claimed to have the felt that the drug hadn't work. Indeed, sulfadoxine/pyrimethamine resistance in Ghana is also to found (WHO, 2006a). Looking at the distribution of antimalarials in Fig. 19, it can be seen that artemisinin and derivates are favoured.

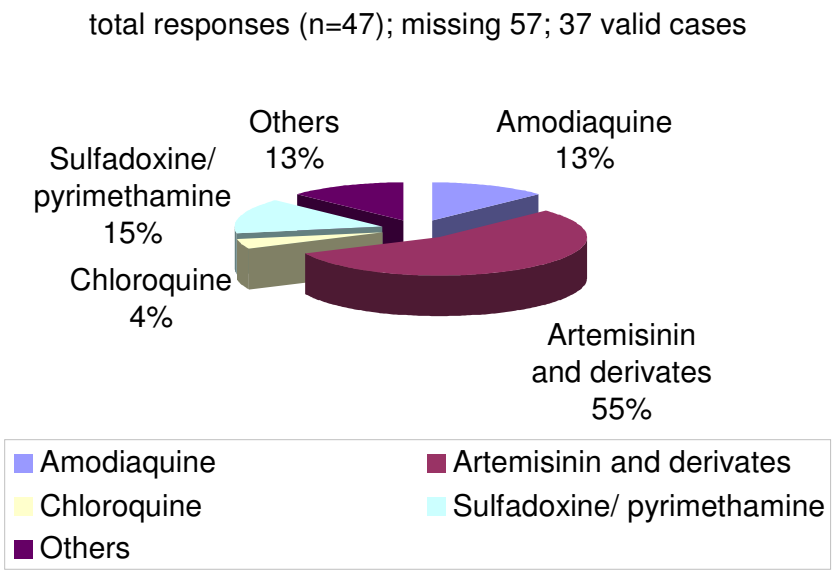

Fig.19: Distribution of the used antimalarials (total responses=47)

Antibiotics

Antibiotics open a large spectrum of possible substances being in use. In the estimation of the drugs used in the Greater Accra region, the use of antibiotics was particularly high, of which hospitals distributed the most. Multiple antibiotics were prescribed in infectious diseases, non-infectious diseases such as cold, diarrhoea or even malaria. Due to tricky names it is assumed that interviewed persons forget or denied the use of antibiotics, because they were not mentioned often. Only fifteen responses from twelve valid cases were registered (Fig. 20). Amoxicillin and metronidazole also known as Flagyl ® are popular antibiotics among the students and staff at VVU. Indeed, regarding the data from the pharmacies and health facilities these substances belong to the most sold antibiotics. An explanation for this is that amoxicillin is a broadband antibiotic and is suitable for a wide range of infectious diseases. Also local pharmaceutical manufactures make products cheap for common use. If compared data from the hospitals and pharmacies the consumption of antibiotics can be regarded as low at VVU. Nevertheless, infectious diseases were common and antibiotics were received in the health facilities.

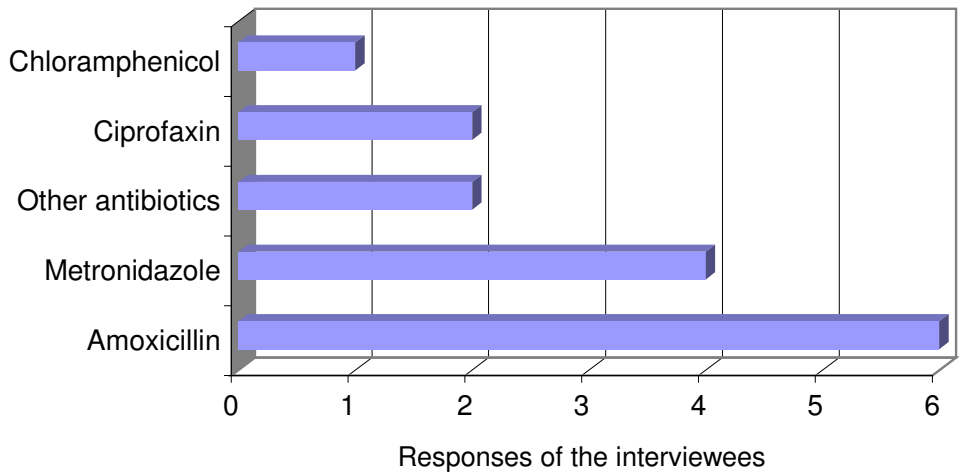

Fig.20: Distribution of antibiotics (total responses=15)

Dietary supplements

Dietary supplements were taken by 28.7 % of the participants. Dietary supplements were not from relevance in this study. But anaemia caused by malaria, worm manifestations or malnutrition is common (MoH, 2004a). It is not surprising that haematinitics[10] or better known blood tonics were used frequently and ranked in 3rd place in the selling of pharmaceutical products in a pharmaceutical wholesale company (Odor, 2007). They were available in village pharmacies as well as in the urban and suburban pharmacies in many variations. Supplements were perceived and prescribed as drugs. A study found that in the ethnic group Ga-Adagbe blood is perceived as the source of life, strength and health (Agyepong et. al., 1997). Proper nutrition can benefit and provide iron and other elements. But proper nutrition was not necessarily put into practice because of inconvenience and costs. This explains why people use haematinics and other dietary supplements. Critics from a non-governmental organisation, argue that the selling of vitamin preparations is harming the people, who already do not have a lot of money at their disposal, instead of encouraging them to buy healthy food (Schaaber et al., 2004).

[10] Dietary supplements such as iron or folic acid for haemoglobin and red-cell production

Herbal medicine

The use of herbals was not dominating but clearly takes on a position with 23.4 % of the n=94 total participants. The different herbs and plant extracts included aloe vera *Aloe vera* (L.) Burm. f., cabbage *Brassica olearaceae,* dandelion, dried paw paw leaves, garlic *Allium sativum* (L.), ginger *Zingiber officinale* Roscoe, lemon *Citrus lemon* (L.) Burm. f., lemon grass *Cymbopogon citratus* (L.), moringa, neem leaves, paw paw and eucalyptus *Eucalyptus camaldulensis* Dehnhardt to name some.

3.6 Overview of active pharmaceutical substances with potential relevance in the environment at VVU

At the VVU, the majority of the students were young and medication aimed mainly at treating pain such as headaches, infectious diseases or malaria. Antidiabetic drugs and drugs in cardiovascular diseases were absent in the interviews and can be neglected for further studies. Relevant therapeutic groups with the active pharmaceutical substances are listed in Table 6 and will be discussed.

Table 6. Overview of active pharmaceutical substances with relevance in the environment at VVU

Therapeutic class	**Pharmaceutical active substance**
Analgesics	Diclofenac, ibuprofen
Antibiotics	*Nitromidazoles* (e.g. metronidazole), *makrolides* (e.g. azithromycin, erythromycin), *tetracyclines* (e.g. doxycyclines), sulfonamides and (e.g. sulfamethoxazole, trimethroprim, sulfadoxine), *chinolenes* (e.g. ciprofloxacin, norfloxacin, ofloxacin)
Antimalarials	Amodiaquine, lumefantrine
Antihelminthics	Albendazole, mebendazole
Antifungals	Clotrimazole

The major therapeutic group used among the students and staff members is the use of *analgesics*. Paracetamol, ibuprofen and acetylsalicylic acid are the major substances. Diclofenac was mentioned to a lesser extent. Paracetamol has

been estimated to be the most sold pharmaceutical active substance among the painkillers. The substance is metabolised predominantly in the liver and is eliminated through the kidneys with urine (Schneider und Richling, 2007). In sewage treatment plants (STP), it is degraded very quickly and in the case of the reuse of human sanitary products at VVU, it is practiced that urine and urine water mixtures are collected in tanks for six months. Due to the high biodegradability of paracetamol and long storage times of human waste it is unlikely that paracetamol will be detected in the environment. Of concern are ibuprofen and diclofenac.

Ibuprofen is considered as a biodegradable compound (Halling-Sorensen et al., 1998; Ternes and Römbke, 2005). Less has been reported about ibuprofen and its metabolites in soil and the terrestrial fauna. However, ibuprofen has the ability to accumulate in soil or aquatic organisms such as algae, which makes it relevant for further investigation at VVU, if liquid urine is applied to soil.

The majority of diclofenac is excreted with urine and partly with faeces in conjugated metabolites. Elimination of diclofenac in water via photodegradation has been emphasised in several studies (Heberer, 2002; Ashton et al., 2004), and can be consulted if diclofenac is detected in urine, perhaps pre-treatment with UV-radiation or the sunlight during the application in the field might be an option to achieve ineffectiveness of the active pharmaceutical compound.

The most frequently used substances to treat malaria were artemisinin derivates, amodiaquine, sulfadoxine and pyrimethamine. Other substances included quinine and lumefantrine. Artemisinin derivates are derived partly from natural origins and are not considered. According to the new drug policy in Ghana, artemether with lumefantrine, artesunate with amodiaquine or artesunate with sulfadoxine/pyrimethamine were the suggested treatment options in malaria (WHO, 2006b). Chloroquine has not been used very often and its use in human medication may decline in Ghana, due to the drug policy. In studies about PhaR antimalarial drugs have been neglected so far, and only little has been reported about the currently used drugs such as amodiaquine

and lumefantrine. Sulfadoxine and pyrimethamine are considered under antibiotic drugs. Artemisinin derivates were derived from natural origins and are not further discussed.

Antibiotics mentioned in the interviews included amoxicillin, chloramphenicol, ciprofloxacin, metronidazole, and roxithromycin. Active pharmaceutical compounds such as *penicillines* and *cephalosporines* were not relevant due to their quick degradation discussed in the chapter of antibiotic drugs. However, metronidazole has been used frequently among the interviewed people and is discussed controversially about its fate and effects in the environment. Due to a precautionary principle and the estimated high consumption it belongs to the substances recommended for further research. Metronidazole belonging to the *nitromidazoles* is likewise excreted via urine and faeces. Alexy (2003) reported that metronidazole is sensitive towards photo-radiation and high temperatures. Temperatures of 20°C and light led to decrease the half-life of the active compound from 66 days to 15 days. Without the influence of light, the half-life is reduced to 60 days. This property has an advantage at VVU, there urine and urine water mixture is stored in the black tanks. High temperatures in the tank during the storage may eliminate the metronidazole. After the application of urine and urine water mixture metronidazole residues are to be expected to leach due to its low adsorption onto organic matter with its log $_{pow}$ -0,02 and may be relevant in waterbodies.

Sulfamethoxacole, belonging to the *sulfonamides* is excreted predominately in its metabolites with urine. About 15–30 % of the substance is excreted in its active form. Sulfamethoxacole is known to be persistent, but elimination through photo-oxidation is possible (Anonymous, 2007). Trimethroprim, another *sulfonamide* excreted predominantly with urine in its pharmaceutical components, is also known to be non-biodegradable in the environment but ozonation is a method to remove the trimethroprim and sulfamethoxacole residues in the sewage effluent (Ternes et al., 2003). However, UV-radiation in high doses helped to eliminate trimethroprim as well (Anonymous, 2007). Trimethroprim and sulfamethoxacole both applied as cotrimoxazole is estimated to be sold at 7.5 t per year are likely to be found in the urine and urine mixture

at VVU. Sulfadoxine another *sulfonamide* in combination with pyrimethamine is applied in malaria. Insufficient data on sulfadoxine could be found. Pyrimethamine is applied in very low amounts at an estimated 3 kg per year due to the low therapeutic doses and can be neglected in further studies.

Among the *chinolenes* the most frequently used substance was ciprofloxacin .In literature, it can be found that ciprofloxacin is persistent in the environment (Estevez et al., 2005). Elimination through photooxidation in drinking water is possible (Ternes et al., 2004). This characteristic indicates that pre-treatment of urine may remove the remainder of the chinolenes. The already practised irrigation of urine and urine-water mixture at VVU, may enable the degradation of PhaR on topsoil through sunlight exposure. However, ciprofloxacin with its log $_{pow}$ of 0.28 indicates a bad adsorption to soil and is leaching. Sunlight exposure is not effective enough in degradation of PhaR from ciprofloxacin in human waste products. Further investigations on the occurrence and fate of ciprofloxacin in human waste products at VVU are to recommend.

Tetracyclines were frequently discussed in veterinary medicine, where animal manure is applied in agriculture. In livestock about 80 % of the tetracycline is excreted with the faeces and the PhaR are considered to be persistent and to accumulate in soil. Tetracyclines, in particular were found in the topsoil, which indicates that the compounds were not transferred to the subsoil. Long storage times of the animal liquid manure for 12 months at 4 C° did not decrease the concentrations significantly (Höper et al., 2002). In the study area tetracyclines have been estimated to be sold at more than 1,000 kg per year. The amounts are lower in comparison with the other antibiotic groups, but persistent characteristics and less effectiveness of storage of urine and faecal sludge make further investigations on its fate in the environment necessary.

Makrolides such as azithromycin and erythromycin are predominately excreted with faeces and are considered to be persistent (Estevez et al., 2005; Boxall, 2004). Higher concentrations are excreted with faecal matter. In STP, where domestic wastewater is not separated into the different streams, erythromycin is to be found in the sewage effluent but elimination via ozone

treatment is possible (Ternes et al., 2003). Makrolides were not mentioned by the interviewed persons but were applied frequently in hospitals and less through pharmacies. Estimated figures of erythromycin of more than 1,000 kg per year indicate that application might be possible and detection of their residues is not excluded.

The other antibiotics such as gentamicin, secnidazole, thiamphenicol, furazolidone, clindamycin and nalidixic acid are used in smaller amounts in the study area and have not been part of studies about its fate and effect in the environment. At VVU, the used doses may be in very low therapeutic doses that detection may be not possible.

Antifungals were clotrimazole, gentamicin and ketoconazole and are applied as ointments or suppositories onto skin at VVU. PhaR will enter the environment via grey water, which is used for irrigation in the surrounding fields as long as they are not excreted with urine or faecal matter. Among the antifungal drugs, clotrimazole is the most applied drug at an estimated 30 kg per year in the study region. In comparison, the total amount of clotrimazole in Germany was 2.8 t in 2002 (OSPAR, 2005), which is three times more if extinguished from 3 million people. The substance shows good adsorption on soil with its log $_{pow}$ of 6.2 and indicates a long half-life of more than 60 days (Pescka et al., 2007; OSPAR, 2005). Due to persistence and possible effects to the soil fauna if grey water is used for irrigation in the long term, the occurrence of clotrimazole is of interest.

Mebendazole and albendazole were used as *antihelminthics* and have not been an object in the studies in PhaR. Estimated figures were low but they are substances taken regularly among the interviewed persons at VVU and should be further investigated.

Hardly any of the women mentioned hormonal *contraceptives.* Sexual activities are discouraged on campus due to religious reasons. Nevertheless, methods such as implants and injection were mentioned. The use of hormonal contraceptives is very low in the study area. Among the other therapeutic

groups *antitussiva* with the substance diphenhydramine, *antihistamines* with cetirizine, chlorphenamine and prednisolone has been mentioned. In *antidiarrhoeals* loperamide, in the antiamoebic secnidazole and in *laxatives* bisacodyl were mentioned. Also other substances were activated charcoal, bicarbonate, ointments containing analgesics, sulphur or aetheric oils, amphetamines, lozenges trisilicate, *nutrition supplements, personal care products such as* antiseptic mouthwash, antifungal soap and *herbal medicine.*

Overall, long storage time of the urine can work as a pre-treatment, where microbial activity, heat and time lead to destruction of PhaR as well as certain retention times of the faecal matter in the biogas digester. In that case, the collection of human waste products can be more beneficial than directly discharged into the environment or treatment in a STP, where the retention time is short at about eight to ten hours.

PhaR excreted predominately through the biliary system with faecal matter are charged into the biogas digester, where long retention time and microbial activity are also to be expected.

In the elimination of PhaR, photo-oxidation is a successful tool in diclofenac, ciprofloxacin, sulfamethoxacole, trimethroprim (Anonymous, 2007) and metronidazole (Alexy, 2003). This form of degradation is also efficient under field conditions, when animal slurry with antibiotic residues is spread on soil surfaces (Thiele-Bruhn and Peters, 2007).

The source separation of human waste into yellow water (urine and water), black water (faeces urine and water) and grey water (kitchen and influent from bathroom) makes it possible, to investigate treatment options to eliminate PhaR at its source.

Another benefit for degrading PhaR is that urine and urine-water mixture are applied in agriculture. PhaR in soil may have a stronger interference with the soil fauna and are degraded (Grote et al., 2005), but possible interactions within the bacterial fauna are not excluded. Possible toxicity towards bacteria through antibiotic residues is the main purpose of the substance and should be considered seriously (Sattelberger, 1999). Further investigations, on the occurrence of PhaR in human waste products at VVU are required to discuss their fate and behaviour in the ecosystem.

4 Conclusions

In recent years, the issue of pharmaceutically active residues, which enter the environment from human and veterinary medicine use via sewage treatment plants, application of animal manure or its direct discharge, has been frequently discussed. At VVU, where ecological sanitation is being practised, human waste products are collected and reused as a fertiliser in the surrounding fields. The immediate question, which arose, was which PhaR (Pharmaceutical active residues) could be expected.

Nonetheless, different climatic and socio-economic conditions and health problems exist at VVU in Ghana, in comparison to developed countries such as Germany. Results from the calculations conducted, concerning the drug sales in the Greater Accra region pronouncedly revealed that infectious diseases and malaria are much more widespread in Ghana than in Germany. The vast proportion of infectious diseases is thus bound to a high consumption of antibiotics, which were predominately dispensed by the hospitals.

A vast proportion of the antibiotics belong to a group, which has a beta-lactam ring that is easily degradable, and this requiring no further investigation. For several others such as metronidazole, azithromycin, erythromycin, tetracyclines, sulfamethoxacole, trimethroprim, sulfadoxine and ciprofloxacin, investigations on their impact in the agroecosystem were perceived as important.

Research regarding the fate of antimalarial drug residues in the environment is quite limited. Resistance of the malaria-causing *Plasmodium* parasite forced the drug policy to shift away from chloroquine to artemisinin derivates and amodiaquine medication. The availability of chloroquine at the pharmacy market is therefore likely to decline in future and newer drugs such as amodiaquine or lumefantrine may become relevant.

In increasing comparability to Germany, cardiovascular diseases (CVD) and non-insulin-dependent diabetes mellitus are becoming more common in the Greater Accra region. From the data collected, nifedipine, atenolol and methyldopa in CVD were drugs of interest, as was metformin in non-insulin-dependent diabetes mellitus. Among the painkillers, paracetamol was the most

frequently used drug followed by ibuprofen, diclofenac and naproxen. Paracetamol is easily degraded but the other analgesics listed should be the focus of further research.
The use of antiretroviral drugs in HIV/AIDS and neoplasm can be cast aside. Drugs in HIV/AIDS were available to a very small proportion of the patients.
Possible endocrine activity from hormones and oral contraceptives due to ethinylestradiol, were extremely unlikely due to the fact that hormonal contraceptives were consumed in small amounts in comparison to developed countries.

Investigations in rural areas demonstrated that the consumption of pharmaceuticals is dependent on their affordability and availability. The use of drugs in CVD and non insulin-dependent diabetes mellitus, and also oral contraceptives were not observed. Scepticism on the drugs was seen as the main barriers. Amongst lifestyle diseases, hypertension and non insulin-dependent diabetes mellitus in both urban and rural areas of the study region are on the rise and an increase in the sale of drugs can be expected in future.
Both rural and urban areas were observed to commonly share a high incidence of malaria and infectious diseases. The group discussions demonstrated that drug intake might be dependent on seasonal changes. The rainy season in June and July were associated with higher cases of malaria, whereas in the dry season headache and skin problems were common complaints. Additionally characteristic for the study area was the consumption of herbal medicine, which was used by several individuals amongst the group discussions and in the interviews at VVU. The consumption of traditional herbal medicine is supplementary to pharmaceutical products obtained in health centres.

At VVU, the majority of the residents were young. Major health problems were malaria and infectious diseases. The residents relied on painkillers, antimalarials and to lesser extent antibiotics, antihelminthics and antifungal drugs. Overall, at VVU active pharmaceutical compounds such as diclofenac, ibuprofen, metronidazole, azithromycin, erythromycin, tetracycline, sulfamethoxacole, trimethroprim, sulfadoxine, ciprofloxacin, amodiaquine,

lumefantrine, albendazole, mebendazole and clotrimazole should be considered for further investigations on their potential relevance in the agroecosystem.
For the reuse of human waste products, seasonal variations of drug intake, waste storage conditions of human waste, its post-application under field conditions, abiotic and biotic factors in the environment have to be taken into account. These criteria influence the activity of pharmaceutical substances.

Future studies should focus on the analysis of urine, faecal sludge, biogas effluent and soil at VVU, which may reveal which PhaR are actually detectable and whether the found concentrations require further attention. Due to the occurrence of PhaR in the environment, the development of effective drugs, with no or little impact on non-target organisms would be desirable. Information on the fate and environmental effects on PhaR and its metabolites, however, remains scarce, particularly regarding ecological sanitation. More research on the occurrence of PhaR and its effects on the environment are important, in order to discover ways for its reduction at source, and to ensure an increasing reuse of human waste products in agriculture.

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6 Appendix

Location of the visited health facilities

Health Facilities	Location	Information available
1. 24h Dispensary	Adabraka	Yes
2. Adenta Pharmacy	Adenta	Yes
3. Adenta Clinic	Adenta Interview with a doctor	No
4. Agvin Pharmacy	Madina	No Response
5. Airport Clinic	Legon	Yes
6. Bentash Kente Link	Spintax	No Response
7. Bethesda Pharmacy	Spintax	No Response
8. Betvin Pharmacy	Madina	Yes
9. Cristallife	Spintax	No Response
10. Danpong	Spintax	Yes
11. Dodowa Davjoel Pharmacy LTD.	Dodowa	No Response
12. East Cantonments	Nkrumah Avenue	No Response
13. Jo Jem Pharmacy Spintex	Spintax Road	No Response
14. Korle Bu Teaching Hospital	Bu	Yes
15. Lardicare	Tema	No Response
16. Lexbet	Rawlings Circle	No Response
17. Lolisa Pharmacy Lashibi	Lashibi Roundabout	No Response
18. Longview Pharmaceutical CO LTD.	Mamprobi Kojo Thompson Road Accra	No Response
19. Mal Titi Madina	Madina	Yes
20. Merchant 2000 LTD. Pharmacy	Dodowa-Road Amarahia	Yes
21. Mother Love	Amarahia	Yes
22. Old Road Chemist Medina	Madina	Yes
23. Olives	Madina	No Response
24. Parker	Bu	Yes

25. PharmaScientific	East Legon	Yes
26. Samanah	Madina	Yes
27. Sterlab Chemist	Bu	Yes
28. Telad	Adenta-Aburi Road	Yes
29. The Pillbox in Adrabraka	Adabraka	Yes
30. Top Up Pharmacy LTD. Tema	Interview with pharmacist Richard Odor	-
31. Unichem	Wholesaler North Industrial Area	Yes
32. Unicom	Spintax Road	Yes
33. Vynne	Madina	No Response
34. Dodowa Health Centre	Dodowa	No Response
35. Military Hospital	37 Interview with a pharmacist	No Response
36. Pantang	Adenta	No Response
37. Greater Grace	Adenta	No Response
38. Family Planning Department	Korle-Bu	Yes
39. M and G	Adabraka	No Response
40. Spintax Clinic	Spintax Road	No Response
41. Kina Pharma	North Industrial Area Wholesaler, Manufacturer	No Response
42. Auntie Esther	VVU Campus Primary Health Care	Yes
43. Adomrobe	Primary Heath Care Village	Yes
44. Bawaleshi	Primary Health Care Village	Yes
45. Ayikuma	Primary Health Care Village	Yes

Questionnaire modified after standard methodology WHO, 1993

Hello
I'm a M. Sc. Student at Valley View University, Accra, Ghana and University of Hohenheim in Germany. I'm doing an assessment about the use of major pharmaceuticals in the region Greater Accra to investigate potential pharmaceutical residues in human waste products.

Thank you very much in advance dealing with my questionnaire.

Question 1: Please name the major health problems in your area?

1.
2. _____
3. _____

Question 2: Which of the following substances are being sold? Preferably over the year, if this is not possible the average in a month or week in the rainy season will do.

Therapeutic Group **Substance**	**Strength**	**Number of purchase** **(Quantity)** **Year/ month/ week**
1. Analgesics, Antipyretics Acetylsalicylic acid Diclofenac Ibuprofen Paracetamol Others (please name)		
2. Antimalarial drugs Artesunate Amodiaquine Sulfadoxine/pyrimethamine Others (please name)		
3. Antibiotics Amoxicillin Ampicillin Cloxacillin Flucloxacillin Chloramphenicol Clotrimoxazole Doxycycline Others (please name)		
4. Antihelminthics Albendazole Mebendazole Ivermectin Others (please name)		
5. Drugs used in Diarrhoea Codeine Loperamide Others (please name)		
6. Cardiovascular Drugs		

Nifedipine Propranolol Atenolol Others (please name)		
7. Insulin and other Antidiabetic drugs Glibenclamide Metformin Others (please name)		
8. Antineoplastic and immunosuppressive drugs Busulfan Cisplatin Chlorambucil Others (please name)		
9. Drugs for HIV/AIDS Abacavir Didanosine Efavirenz Others (please name)		
10. Hormones other endocrine drugs and contraceptives Conjugated Oestrogen Conjugated Oestrogen+ Norgesterol Others (please name)		
11.Others (please name)		

Comment: _____

_____

_____

I will collect these sheets in the following week: _____

Please do not hesitate to contact me if you have any questions concerning my research. The response you give will be treated with confidentiality. This collection of data is only for research purpose and has no direct benefit.

Sincerely,

Evren Sinar

Drugs by the hospitals and health centres

Therapeutic group	Substance	Korle Bu	Airport	Sum	Mean (150/2)	Kilo	Kilo Co-substance
Analgesics	Paracetamol 500 mg	898000	104814	1002814	75211050	37605,5	0
Analgesics	Paracetamol 120 mg/ 15 ml	20	0	20	1500	0,2	0
Analgesics	Paracetamol125 mg/ 5 ml	9980	0	9980	748500	93,6	0
Analgesics	Paracetamol supp 125 mg	1480	0	1480	111000	13,9	0
Analgesics	Paracetamol supp 250 mg	3660	0	3660	274500	68,6	0
Analgesics	Ibuprofen 100 mg/ 5 ml	1260	0	1260	94500	9,5	0
Analgesics	Ibuprofen 200 mg	30000	0	30000	2250000	450	0
Analgesics	Ibuprofen 400 mg	128000	18942	146942	11020650	4408,3	0
Analgesics	Naproxen 500 mg	35388	0	35388	2654100	1327	0
Analgesics	Diclofenac 50 mg	381400	0	381400	28605000	1430,2	0
Analgesics	Diclofenac 75 mg	9100	0	9100	682500	51,2	0
Analgesics	Diclofenac 100 mg	24026	0	24026	1801950	180,2	0
Analgesics	Diclofenac ointment	700	0	700	52500	0	0
Analgesics	Triamicinolone Inj 10 mg	400	0	400	30000	0,3	0
Anthelminitics	Mebendazole 5 mg/ 30 ml (100 ml)	200	0	200	15000	0,3	0
Anthelminitics	Mebendazole 100 mg	240	0	240	18000	1,8	0
Anthelminitics	Mebendazole 500 mg	2220	0	2220	166500	83,3	0
Anthelminitics	Albendazole 400 mg/ 10 ml	730	0	730	54750	21,9	0
Antiasthmatic drugs	Salbutamol 4 mg	35000	0	35000	2625000	10,5	0
Antiasthmatic drugs	Salbutamol Syrup	30	0	30	2250	0	0
Antiasthmatic drugs	Salbutamol Inhalation 5 mg/ ml 100 mg	370	0	370	27750	2,7	0
Antiasthmatic drugs	Salbutamol Inhalation 2,5 mg	5500	0	5500	412500	0,3	0
Antidiabetic drugs	Glibenclamide 5 mg	267830	68106	335936	25195200	126	0
Antidiabetic drugs	Glimepride 2 mg	0	600	600	45000	0,09	0
Antidiabetic drugs	Metformin 500 mg	320550	69841	390391	29279325	14639,6	0
Antidiabetic drugs	Tolbutylamide 5 mg	28784	0	28784	2158800	10,8	0
Antifungal	Clotrimazole	0	842	842	63150	30,3	0
Antifungal	Miconazole 20 mg/ g ointment	0	854	854	64050	1,3	0
Antifungal	Isoconazole ointment	0	794	794	59550	0	0
Anti-inflammatory drugs	Hydrocortisone 100 mg	9650	0	9650	723750	72,4	0
Antiinfective	Amoxicillin 250 mg	257300	42518	299818	22486350	5621,6	0
Antiinfective	Amoxicillin 500 mg	87400	0	87400	6555000	3277,5	0
Antiinfective	Amoxicillin+Clavulanic	163071	18020	181091	13581825	6791	1697,7

	acid 625 mg (500+125)						
Antiinfective	Amoxicillin+Clavulanic acid 1g (875+125)	8862	0	8862	664650	581,6	83,1
Antiinfective	Amoxicillin+Clavulanic acid 1,2 g (1000+200 mg)	7770	0	7770	582750	582,7	116,5
Antiinfective	Amoxicillin+Clavulanic acid 600 mg (500+100 mg)	14740	0	14740	1105500	552,7	110,5
Antiinfective	Amoxicillin+Clavulanic acid Inj 1g+25 mg	4015	0	4015	301125	301,3	7,5
Antiinfective	Amoxicillin+Clavulanic acid 288 mg/ 5 ml	2282	0	2282	171150	49,3	0
Antiinfective	Erythromycin 250 mg	62760	17309	80069	6005175	1501, 3	0
Antiinfective	Erythromycin 125 mg	320	0	320	24000	3	0
Antiinfective	Flucloxacillin 500 mg	9350	0	9350	701250	350,6	0
Antiinfective	Flucloxacillin 150 mg	3700	0	3700	277500	41,6	0
Antiinfective	Flucloxacillin 125 mg/ 5 ml	108	0	108	8100	4	0
Antiinfective	Flucloxacillin 250 mg	475000	44309	519309	38948175	9737	0
Antiinfective	Flucloxacillin 125 mg	3780	0	3780	283500	35,4	0
Antiinfective	Azithromycin 250 mg	0	6444	6444	483300	120,8	0
Antiinfective	Azithromycin 200 mg/ 5 ml	920	0	920	69000	276	0
Antiinfective	Cefuroxamine axetil 125 mg	1341	0	1341	100575	12,6	0
Antiinfective	Cefuroxime axetil 250 mg	24800	9951	34751	2606325	651,6	0
Antiinfective	Cefuroxime sodium 750 mg	14085	584	14669	1100175	825,1	0
Antiinfective	Cefuroxmine axetil 750 mg	1875	0	1875	140625	105,5	0
Antiinfective	Ceftriaxone 500 mg	20	0	20	1500	0,7	0
Antiinfective	Ceftriaxone 1g	10120	480	10600	795000	795	0
Antiinfective	Co-trimoxacole (80 mg Trimethroprim+ Sulphamethoxazole) 400 mg	236000	5489	241489	18111675	7244, 7	1449
Antiinfective	Co-trimoxacole 240 mg/ 5 ml (40+200)	1330	0	1330	99750	20	4
Antiinfective	Metronidazole 500 mg	52838	0	52838	3962850	1981, 4	0
Antiinfective	Metronidazole 200 mg	523000	43247	566247	42468525	8493, 7	0
Antiinfective	Metronidazole 100 mg/ 15 ml	1315	0	1315	98625	82,8	0
Antiinfective	Secnidazole 500 mg	3530	4040	7570	567750	283,9	0
Antiinfective	Ciprofloxacin 500 mg	69200	24722	93922	7044150	3522	0
Antiinfective	Ciprofloxacin 200 mg/ 100 ml	10957	0	10957	821775	164,4	0
Antiinfective	Ciprofloxacin 200 mg	6752	0	6752	506400	101,3	0
Antiinfective	Ciprofloxacin eye drops	230	0	230	17250	0	0
Antiinfective	Gentamicin 40 mg/ 2ml	0	818	818	61350	2,5	0
Antiinfective	Chloramphenicol 1 g	0	364	364	27300	27,3	0
Antiinfective	Neomycin 500 mg	0	621	621	46575	23,3	0
Antiinfective	Nalidixic Acid 500 mg	0	3256	3256	244200	122,1	0
Antiinfective	Ofloxacin 200 mg	0	8700	8700	652500	130,5	0
Antiinfective	Norfloxacin 400 mg	0	8964	8964	672300	269	0
Antiinfective	Thiamphenicol 250 mg	0	12480	12480	936000	234	0
Antiinfective	Tetracycline 250 mg	58000	0	58000	4350000	1087,	0

						5	
Antiinfective	Tetracycline ointment	1200	0	1200	90000	0	0
Antiinfective	Cloaxicillin 250 mg	32000	0	32000	2400000	600	0
Antiinfective	Cloaxicillin 125 mg/ 5 ml	400	0	400	30000	75	0
Antiinfective	Cloaxicillin 500 mg	15100	0	15100	1132500	566,2	0
Antiinfective	Ampicillin 500 mg	14780	0	14780	1108500	554,2	0
Antiinfective	Penicillin V 250 mg	18000	0	18000	1350000	337,5	0
Antiinfective	Penicillin Inj 1 g	28000	0	28000	2100000	2100	0
Antiinfective	Penicillin V 5 g	12250	0	12250	918750	4593, 7	0
Antiinfective	Clavulinic acid 625 mg	7280	0	7280	546000	341,2	0
Antiinfective	Clindamycin 150 mg	9200	0	9200	690000	103,5	0
Antiinfective	Clindamycin 300 mg	7966	0	7966	597450	179,2	0
Antiinfective	Clindamycin 75 mg	255	0	255	19125	1,4	0
Antimalarial	Artemether 20 mg	0	104241	104241	7818075	156,4	0
Antimalarial	Lumefantrine 120 mg	0	104241	104241	7818075	938,2	0
Antimalarial	Artesunate 200 mg	8390	102616	111006	8325450	1665	0
Antimalarial	Artesunate 100 mg	3550	0	3550	266250	26,6	0
Antimalarial	Amodiaquine 200 mg	26000	0	26000	1950000	390	0
Antimalarial	Amodiaquine 153 mg	0	106216	106216	7966200	1218, 8	0
Antimalarial	Amodiaquine 50 mg/ 5 ml	6531	0	6531	489825	489,8	0
Antimalarial	Sulfadoxine 500 mg	0	1102	1102	82650	41,3	0
Antimalarial	Pyrimethamine 25 mg	0	1102	1102	82650	2	0
Antimalarial	Quinine 500 mg	0	982	982	73650	36,8	0
Cardiovascular drugs	Nifedipine 30 mg	133900	39154	173054	12979050	389,4	0
Cardiovascular drugs	Nifedipine 20 mg	484820	0	484820	36361500	727,2	0
Cardiovascular drugs	Nifedipine 10 mg	270080	0	270080	20256000	202,6	0
Cardiovascular drugs	Amlodipine besylate 5 mg	0	70800	70800	5310000	26,5	0
Cardiovascular drugs	Felodipine 5 mg	0	9000	9000	675000	3,4	0
Cardiovascular drugs	Atenolol 100 mg	117124	27104	144228	10817100	1081, 7	0
Cardiovascular drugs	Atenolol 50 mg	232076	0	232076	17405700	870,3	0
Cardiovascular drugs	Carvedilol 12,5 mg	0	5442	5442	408150	5,1	0
Cardiovascular drugs	Candestartan cilexetil 8 mg	0	13440	13440	1008000	8	0
Cardiovascular drugs	Lisonopril dihydrate 5 mg	68700	68460	137160	10287000	51,4	0
Cardiovascular drugs	Lisonopril 10 mg	69500	0	69500	5212500	52,1	0
Cardiovascular drugs	Bendrofluazide 5 mg	0	29500	29500	2212500	11	0
Cardiovascular drugs	Methyldopa 250 mg	100100	0	100100	7507500	1876, 9	0

Estimated consumption amounts of contraceptives

Product	**Substance**	**Trademark**	**ΣHealth facilities per month**	**Number health facilities per year (n=725) (N=18)**	**Amount**
Oral contraceptives	Norgestrel 0,3 mg Ethinylestradiol 0,03 mg Ferrous fumarate 0,75 mg	Secure, Ovrette	4310	2083166 tab.	Ethinylestradiol 63 g 625 g norgestrel
Oral contraceptives	Norhisterone 0,5 mg Ethinylestradiol 0,035 mg	Micro G	225	108750	3,8 g Ethinylestradiol 54 g norhisterone
Oral contraceptives	Levonorgestrel 0,15 mg Ethinylestradiol 0,003 mg Ferrous fumarate 0,75 mg	Lo femenal/ Microgynon	400	193333	30 g Levonorgestrel 0,5 g Ethinylestradiol
Emergency contraceptives	Levonorgestrel 0,75 mg	Postinor2	715	345583	260 g Levonorgestrel
Injection	5 mg Estradiol 50 mg norhisterone	Norgynon	15	7250	36 mg Estradiol 362 g norhisterone
Injection	Medroxyprogestone 150 mg/ ml	Depo Provera	200	96666	14,5 kg Medroxyprogestone
Implant	Levonorgestrel 36 mg each capsule (six capsules at once)	Norplant	3	1450	313 g Levonorgestrel
Spermicides	Nonoxynol-9 4 mg	Today	1610	778166	3 kg Nonoxynol-9
Spermicides	menfegol	Kamal			
Spermicides	-	Sampoon			

Drugs by the pharmacies separated in rural area

Therapeutic group	Substance	Pharmacies rural	Raising factor rural	Year	Kilo	CL lower	CL higher
Analgesics	Paracetamol 500 mg	352	1760	84480	42,24	-3109,94	3814,94
Analgesics	Ibuprofen 400 mg	437	2185	104880	0,1748	-5121,46	5996,46
Analgesics	Naproxen 500 mg	0	0	0	0	0	0
Analgesics	Diclofenac 100 mg	35	175	8400	0,84	-155,59	225,59
Analgesics	Acetylsalicylic acid 300mg	20	100	4800	1,44	-234,12	274,12
Analgesics	Indometacin 50 mg	0	0	0	0	0	0
Analgesics	EF Pack	0	0	0	0	0	0
Analgesics	Kwick Action	0	0	0	0	0	0
Analgesics	piroxicam 20 mg	0	0	0	0	0	0
Antihelminitics	Mebendazole 500 mg	7,5	37,5	1800	0,9	-77,73	92,73
Antihelminitics	Albendazole 400 mg	7,5	37,5	1800	0,72	-77,73	92,73
Anticonvulsants	Carbamazepine 200 mg	0	0	0	0	0	0
Anticonvulsants	Diazepam 5 mg	0	0	0	0	0	0
Anticonvulsants	Lorazepam 2,5 mg	0	0	0	0	0	0
Anticonvulsants	Buscopan	25	125	6000	0	0	0
Antidiabetic drugs	Gilbenclamide 5 mg	0	0	0	0	0	0
Antidiabetic drugs	Metformin 500 mg	0	0	0	0	0	0
Antidiabetic drugs	Tolbutylamide 5 mg	0	0	0	0	0	0
Antidiabetic drugs	Glizone 30 mg	0	0	0	0	0	0
Antihelminitics	Ivermectin 200 mg	0	0	0	0	0	0
Antihelminitics	Thiabendazole 500 mg	0	0	0	0	0	0
Antihelminitics	Praziquantel 600 mg	0	0	0	0	0	0
Antiinfective	Amoxicillin 500 mg	82,5	412,5	19800	9,9	-400,5	565,5
Antiinfective	Erythromycin 250 mg	1	5	240	0,06	-10,36	12,36
Antiinfective	Flucloxacillin 500 mg	1	5	240	0,12		
Antiinfective	Azithromycin 250 mg	0	0	0	0	0	0
Antiinfective	Cefuroxime sodium 750 mg	0	0	0	0	0	0
Antiinfective	(Co-trimoxacole) Trimethroprim+ Sulphamethoxacole 80 mg+ 400 mg	0	0	0	0	0	0
Antiinfective	Metronidazole 500 mg	20	100	4800	2,4	-207,29	247,29
Antiinfective	Ciprofloxacin 500 mg	5	25	1200	0,6	-51,8	61,8
Antiinfective	Cloaxicillin 500 mg	2	10	480	0,24	-20,7	24,7
Antiinfective	Ampicillin 500 mg	0	0	0	0	0	0

Antiinfective	Penicillin V 250 mg	0	0	0	0	0	0
Antiinfective	Chloramphenicol 1 g	0	0	0	0	0	0
Antiinfective	Doxycycline 100 mg	0	0	0	0	0	0
Antiinfective	Sulphathiazole	0	0	0	0	0	0
Antimalarial	Arthmeter 20 mg	0	0	0	0	0	0
Antimalarial	Lumefantrine 120 mg	0	0	0	0	0	0
Antimalarial	Artemesinin derivates 200 mg	140	700	33600	6,72	-996,47	1276,47
Antimalarial	Amodiaquine 200 mg	250	1250	60000	12	-2591,19	3091,19
Antimalarial	Sulfadoxine 500 mg	0	0	0	0	0	0
Antimalarial	Pyrimethamine 25 mg	0	0	0	0	0	0
Antimalarial	Pyrimethamine (Daraprim) 25 mg	0	0	0	0	0	0
Antimalarial	Chloroquine 1g	0	0	0	0	0	0
Antimalarial	Lariam 250 mg	0	0	0	0	0	0
Cardiovascular drugs	Nifedipine 20 mg	0	0	0	0	0	0
Cardiovascular drugs	Amlodipine besylate 5 mg	0	0	0	0	0	0
Cardiovascular drugs	Atenolol 100 mg	0	0	0	0	0	0
Cardiovascular drugs	Carvedilol 25 mg	0	0	0	0	0	0
Cardiovascular drugs	Lisinopril 10 mg	0	0	0	0	0	0
Cardiovascular drugs	Propanolol 40 mg	0	0	0	0	0	0
Cardiovascular drugs	Crestor 10 mg	0	0	0	0	0	0
Contraceptives	Ethinylestradiol 0,3 mg				0,072	-	-
Contraceptives	Norgestrel 0,03 mg+ Ethinylestradiol 0,3 mg	1	5	240	0,0000007	-145,1	173,1
Contraceptives	Levonorgestrel 0,75 mg	0	0	0	0	0	0
Drugs used in diarrhoea	Loperamide 2 mg	7,5	37,5	1800	0,0036	-87,79	102,79
Drugs used in diarrhoea	Phthalsulphathiazole 500 mg	0	0	0	0	0	0
Drugs used in diarrhoea	Codeine 30 mg	0	0	0	0	0	0
Drugs used in diarrhoea	Bifidac (Probiotics)	0	0	0	0	0	0
Drugs used in diarrhoea	metronidazole+ furazolidone (Metrolex-F) 400 mg+100 mg	0	0	0	0	0	0

Drugs by the pharmacies separated in semi urban area

Therapeutic group	Substance	Pharmacies semi-urban mean	Raising factor semi-urban 235/8	Year semi-urban	Kilo	CL lower	CL higher
Analgesics	Paracetamol 500 mg	3468,7	101894,5	4890937,5	2445,5	-300,6	7238,2
Analgesics	Ibuprofen 400 mg	1362,5	40023,4	1921125	768,4	34,4	2690,5
Analgesics	Naproxen 500 mg	5	146,9	7050	3,5	-6,8	16,8
Analgesics	Diclofenac 100 mg	1278,1	37545	1802163,3	180,2	-70,3	2626
Analgesics	Acetylsalicylic acid 300 mg	451,25	13255,4	636262,5	190,9	84,1	818,3
Analgesics	Indometacin 50 mg	37,5	1101,5	52875	2,6	-51,1	126,1
Analgesics	EF Pack	475	13953,1	669750	0	-409,4	1359,4
Analgesics	Kwick Action	50	1468,7	70500	0	-68,2	168,2
Analgesics	Piroxicam 20 mg	125	3671,9	176250	3,5	-170,5	420,5
Antihelminitics	Mebendazole 500 mg	67,5	1982,8	95175	47,6	34,5	100,4
Antihelminitics	Albendazole 400 mg	94,5	2775,9	133245	53,3	41,8	147,1
Anticonvulsants	Carbamazepine 200 mg	151,5	4450,3	213615	42,7	-202,7	505,7
Anticonvulsants	Diazepam 5 mg	8,75	257	12337,5	0,06	-6,3	23,86
Anticonvulsants	Lorazepam 2,5 mg	0	0	0	0	0	0
Anticonvulsants	Buscopan	0	0	0	0		
Antidiabetic drugs	Gilbenclamide 5 mg	485,6	14265,2	684731,2	3,4	115,7	855,4
Antidiabetic drugs	Metformin 500 mg	315	9253,1	444150	222	64,5	565,4
Antidiabetic drugs	Tolbutylamide 5 mg	0,625	18,4	881,2	0,004	-0,85	2,1
Antidiabetic drugs	Glizone 30 mg	2,5	73,4	3525	0,1	-3,4	8,4
Antihelminitics	Ivermectin 200 mg	4,5	132,2	6345	1,3	-4,2	13,2
Antihelminitics	Thiabendazole 500 mg	16,9	495,6	23786,7	11,9	-23	65,7
Antihelminitics	Praziquantel 600 mg	12,5	367,2	17625	10,6	-17	42
Antiinfective	Amoxicillin 500 mg	1341	39391,9	1890810	945,4	-207,3	2889
Antiinfective	Erythromycin 250 mg	0	0	0	0	0	0
Antiinfective	Flucloxacillin 500 mg	245	7196,9	345450	172,7	-184,9	674,9
Antiinfective	Azithromycin 250 mg	0	0	0	0	0	0
Antiinfective	Cefuroxime sodium 750 mg	0	0	0	0	0	0
Antiinfective	Co-trimoxazole (Trimethroprim+ Sulphamethoxazole) Sulfamethoxazole 400 mg +	64	1880	90240	36,1	8,5	119,4
Antiinfective	Trimethroprim 80 mg				7,2	-	-
Antiinfective	Metronidazole 500 mg	243,7	7160,2	343687,5	171,8	-125,3	682,4

Antiinfective	Ciprofloxacin 500 mg	168	4935	236880	118,4	-117,4	453,4
Antiinfective	Cloaxicillin 500 mg	746,9	21939,3	1053086,7	526,5	82,6	1411
Antiinfective	Ampicillin 500 mg	460	13512,5	648600	324,3	-195,9	1115,9
Antiinfective	Penicillin V 250 mg	12,5	367,2	17625	4,4	-17	42
Antiinfective	Chloramphenicol 250 mg	436,5	12822,2	615465	153,9	-464	1337
Antiinfective	Doxycycline 100 mg	287,5	8445,3	405375	40,5	-76,7	651,7
Antiinfective	Sulphathiazole	6,25	183,6	8812,5	0	-8,5	21
Antimalarial	Arthmeter 20 mg	51	1498,2	71910	1,4	-54,3	156,3
Antimalarial	Lumefantrine 120 mg	51	1498,2	71910	14,4	-54,3	156,3
Antimalarial	Artesunate 200 mg	494,2	14518,6	696892,5	139,4	192,4	796
Antimalarial	Amodiaquine 200 mg	128,6	3778,4	181361,2	36,3	-14,6	271,8
Antimalarial	Sulfadoxine 500 mg (Sulfadoxine/ Pyrethamine)	177,7	5221,4	250627,5	125,3	34,4	321
Antimalarial	Pyrimethamine 25 mg (Sulfadoxine/ Pyrethamine)	177,7	5221,4	250627,5	6,3	34,4	321
Antimalarial	Pyrimethamine (Daraprim) 25 mg	33,7	991,4	47587,5	1,2	-22,2	89,7
Antimalarial	Chloroquine 1 g	33	969,4	46530	46,5	-21,1	87,1
Antimalarial	Lariam 250 mg	0	0	0	0	0	0
Cardiovascular drugs	Nifedipine 20 mg	707,5	21048,1	1010310	20,2	-109,8	1524
Cardiovascular drugs	Amlodipine besylate 5 mg	18,1	532,4	25556,2	0,1	-18,4	54,6
Cardiovascular drugs	Atenolol 100 mg	468,7	13769,5	660937,5	66	-129,9	1067
Cardiovascular drugs	Carvedilol 25 mg	56,3	1652,3	79312,5	2	0	0
Cardiovascular drugs	Lisonopril 10 mg	3,7	110,2	5287,5	0,05	-5,1	12,6
Cardiovascular drugs	Propranolol 40 mg	0	0	0	0	25,2	165,4
Cardiovascular drugs	Crestor 10 mg	17,5	514	24675	0,25	-23,8	58,8
Contraceptives	Ethinylestradiol 0,3 mg				0,04	-	-
Contraceptives	Norgestrel 0,03 mg	110,25	3238,6	155452,5	0,004		
Contraceptives	Levonorgestrel 0,75 mg	8,125	238,7	11456,2	0,008		
Drugs used in diarrhoea	Loperamide 2 mg	371,9	10923,7	524336,7	1	30,8	713,1
Drugs used in diarrhoea	Phthalsulphathiazole 500 mg	62,5	1836	88125	44	-85,2	210,2
Drugs used in diarrhoea	Codeine 30 mg	0	0	0	0	0	0
Drugs used in diarrhoea	Bifidac (Probiotics)	7,5	220,3	10575	0	-10,2	25,5
Drugs used in diarrhoea	Metrolex F (metronidazole+ furazolidone) 400 mg metronidazole	41,25	1211,7	58162,5	23,3	-28,9	111,4
Drugs used in diarrhoea	Furazolidone 100 mg				5,81	-	-

Drugs by the pharmacies separated in the urban area

Therapeutic groups	Substance	Pharmacies urban (all in weekly n= 7) Mean	Raising factor urban 180/7	Year urban	Kilo	CL lower urban	CL higher urban
Analgesics	Paracetamol 500 mg	1828,6	47020,4	2256978	1128,5	511,1	3145,9
Analgesics	Ibuprofen 400mg	1742,9	44816,4	2151187,2	860,5	-99,1	3584,8
Analgesics	Naproxen 500 mg	35,7	918	44076,3	22,1	-33,4	104,8
Analgesics	Diclofenac 100 mg	1367,1	35155	1687441,4	168,7	-170,8	2905,1
Analgesics	Acetylsalicylic acid 300mg	398,6	10249	491949,3	147,6	-110,8	907,9
Analgesics	Indometacin 50 mg	0	0	0	0	0	0
Analgesics	EF Pack[11]	0	0	0	0	0	0
Analgesics	Kwick Action[12]	0	0	0	0	0	0
Analgesics	Piroxicam 20 mg	1,4	36,5	1752,7	0,03	0	0
Anthelminitics	Mebendazole 500 mg	30,9	793,3	38077,7	19	-2,5	64,2
Antihelminitics	Albendazole 400 mg	47,3	1216	58357	23,3	6,6	87,9
Anticonvulsants	Carbamazepine 200 mg	25,7	661,1	31733,5	6,3	-25,4	76,8
Anticonvulsants	Diazepam 5 mg	14,3	367,2	17625,6	0,08	-0,68	29,2
Anticonvulsants	Lorazepam 2,5 mg	2,8	73,3	3517,7	0,008	-4,1	9,8
Anticonvulsants	Buscopan	0	0	0	0		
Antidiabetic drugs	Gilbenclamide 5 mg	704,3	18110	869282,7	4,3	-281,21	1689,7
Antidiabetic drugs	Metformin 500 mg	1104,3	28395,7	1362997	681,5	-610,9	2819,5
Antidiabetic drugs	Tolbutylamide 5 mg	0	0	0	0	0	0
Antidiabetic drugs	Glizone 30 mg	0	0	0	0	0	0
Antihelminitics	Ivermectin 200 mg	0,3	7,2	345,6	0,06	-0,4	0,9
Antihelminitics	Thiabendazole 500 mg	0	0	0	0	0	0
Antihelminitics	Praziquantel 600 mg	0	0	0	0	0	0
Antiinfective	Amoxicillin 500 mg	998,6	25677,5	1232522,5	616,2	-251,8	2249
Antiinfective	Erythromycin 250 mg	8,6	220,4	10579,6	2,6	-12,4	29,5
Antiinfective	Flucloxacillin 500 mg	477,4	12269,4	588930,6	294,5	-173	1127,3
Antiinfective	Azithromycin 250 mg	11,4	293,9	14106,1	3,5	-9,5	32,4
Antiinfective	Cefuroxime sodium 750 mg	2,9	73,5	3526,5	2,6	-4,13	9,8
Antiinfective	Co-trimoxacole (Trimethroprim+ Sulphamethoxazole) 400 mg Sulphamethoxazole	231,4	5951,05	285650,7	114,3	-86,5	549,4
Antiinfective	Trimethroprim 80 mg				22,8		
Antiinfective	Metronidazole 500 mg	577,1	14840,8	712359,2	356,2	-30	1184
Antiinfective	Ciprofloxacin 500 mg	134,3	3453	165745	82,9	-27,5	296,1
Antiinfective	Cloaxicillin 500 mg	434,3	11167,2	536025,6	268	-221,3	1089,9
Antiinfective	Ampicillin 500 mg	85	2185,7	104914,3	52	1,2	168,7
Antiinfective	Penicillin V 250 mg	0	0	0	0	0	0
Antiinfective	Chloramphenicol	20	514,3	24685,7	6,2	0	0

[11] Combination of 150 mg acetylsalicylacid, 250 mg paracetamol, 35 mg caffeine and
[12] Combination of 500 mg paracetamol, 30 mg caffeine and 10 mg ephedrine

	250 mg						
Antiinfective	Doxycyclines 100 mg	288,6	7420,4	356179,6	35,6	-96	553,2
Antiinfective	Sulphathiazole	0	0	0	0	0	0
Antimalarial	Artemether 20 mg	7,1	183,6	8812,8	0,2	0	0
Antimalarial	Lumefantrine 120 mg	7,1	183,6	8812,8	1,1	0	0
Antimalarial	Artesunate 200 mg	551,1	14172,2	680264,2	136	117	985
Antimalarial	Amodiaquine 200 mg	120,6	3100,4	148817,8	29,8	-38	279,1
Antimalarial	Sulfadoxine 500 mg (Sulfadoxine/ Pyrimethamine)	106,1	2729,3	131007	65,5	9,2	203
Antimalarial	Pyrimethamine 25 mg (Sulfadoxine/ Pyrethamine)	106,1	2729,3	131007	3,3	9,2	203
Antimalarial	Pyrimethamine 25 mg (Daraprim)	17,9	459	22032	0,5	-23,8	59,5
Antimalarial	Chloroquine 1g	41,1	1057,9	50778,5	50,7	-25,3	107,6
Cardiovascular drugs	Nifedipine 20 mg	557,1	14326,5	687670	13,7	-120,8	1235,1
Cardiovascular drugs	Amlodipine besylate 5 mg	0	0	0	0	-57,8	137,8
Cardiovascular drugs	Atenolol 100 mg	376,4	9679,6	464622,1	46,5	-96,5	849,4
Cardiovascular drugs	Carvedilol 25 mg	0	0	0	0	0	0
Cardiovascular drugs	Lisonopril 10 mg	17,1	440,7	21155,6	0,2	-24,8	59
Cardiovascular drugs	Propranolol 40 mg	720	18514,3	888685,7	35,5	-627	2067
Cardiovascular drugs	Crestor 10 mg	0	0	0	0	0	0
Contraceptives	Ethinylestradiol 0,3 mg				0,03		
Contraceptives	Norgestrel 0,03 mg	99,6	2560,4	122897,8	0,0001		
Contraceptives	Levonorgestrel 0,75 mg	9	231,4	11108,5	0,008		
Drugs used in Diarrhoea	Loperamide 2 mg	147,1	3783,6	181612,8	0,36	41	253,2
Drugs used in Diarrhoea	Phthalsulphathiazole 500 mg	3	77,2	3702,9	1,8	-4,3	10,3
Drugs used in Diarrhoea	Codeine 30 mg	0,8	20,6	987,4	0,02	-1,24	2,95
Drugs used in Diarrhoea	Bifidac (Probiotics)	0	0	0	0	0	0
Drugs used in Diarrhoea	(Metrolex F) metronidazole 400 mg+ 100 mg furazolidone	0	0	0	0	0	0

Data about the respondents at Valley View University

Sex

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	1 female	43	45,7	45,7	45,7
	2 male	51	54,3	54,3	100,0
	Gesamt	94	100,0	100,0	

Age

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	18	2	2,1	2,2	2,2
	19	8	8,5	8,8	11,0
	20	16	17,0	17,6	28,6
	21	8	8,5	8,8	37,4
	22	9	9,6	9,9	47,3
	23	5	5,3	5,5	52,7
	24	3	3,2	3,3	56,0
	25	5	5,3	5,5	61,5
	26	5	5,3	5,5	67,0
	27	4	4,3	4,4	71,4
	28	3	3,2	3,3	74,7
	29	1	1,1	1,1	75,8
	30	1	1,1	1,1	76,9
	31	1	1,1	1,1	78,0
	32	1	1,1	1,1	79,1
	34	1	1,1	1,1	80,2
	35	2	2,1	2,2	82,4
	37	3	3,2	3,3	85,7
	39	4	4,3	4,4	90,1
	42	1	1,1	1,1	91,2
	43	1	1,1	1,1	92,3
	44	1	1,1	1,1	93,4
	45	2	2,1	2,2	95,6
	46	1	1,1	1,1	96,7
	48	1	1,1	1,1	97,8
	52	1	1,1	1,1	98,9
	54	1	1,1	1,1	100,0
	Gesamt	91	96,8	100,0	
Fehlend	99	3	3,2		
Gesamt		94	100,0		

Occupation

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	1 student	70	74,5	76,1	76,1
	2 Employee	22	23,4	23,9	100,0
	Gesamt	92	97,9	100,0	
Fehlend	99	2	2,1		
Gesamt		94	100,0		

Malaria

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Malaria	39	41,5	41,5	41,5
	1 malaria	55	58,5	58,5	100,0
	Gesamt	94	100,0	100,0	

Infections

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Infection	72	76,6	76,6	76,6
	1 infection	22	23,4	23,4	100,0
	Gesamt	94	100,0	100,0	

Skin diseases

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No skin diseases	87	92,6	92,6	92,6
	1 skin diseases	7	7,4	7,4	100,0
	Gesamt	94	100,0	100,0	

Diarrhoeal Diseases

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Diarrhoe	87	92,6	92,6	92,6
	1 Diarrhoe	7	7,4	7,4	100,0
	Gesamt	94	100,0	100,0	

Hypertension

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Hypertension	94	100,0	100,0	100,0

Acute Eye Infection

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No acute eye infection	91	96,8	96,8	96,8
	1 acute eye infection	3	3,2	3,2	100,0
	Gesamt	94	100,0	100,0	

Rheuma and joint pain

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Rheuma	78	83,0	83,0	83,0
	1 Rheuma	16	17,0	17,0	100,0
	Gesamt	94	100,0	100,0	

Anaemia

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Anaemia	84	89,4	89,4	89,4
	1 Anaemia	10	10,6	10,6	100,0
	Gesamt	94	100,0	100,0	

Worm Infestations

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No Worms	89	94,7	94,7	94,7
	1 Worms	5	5,3	5,3	100,0
	Gesamt	94	100,0	100,0	

Pain

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No pain	63	67,0	67,0	67,0
	1 pain	31	33,0	33,0	100,0
	Gesamt	94	100,0	100,0	

Others

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No other diseases	59	62,8	62,8	62,8
	1 other diseases	35	37,2	37,2	100,0
	Gesamt	94	100,0	100,0	

Acetylsalicylic acid

	Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente

Gültig	0 No Acetylsalicylic acid	85	90,4	90,4	90,4
	1 ASS	9	9,6	9,6	100,0
	Gesamt	94	100,0	100,0	

Diclofenac

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 No diclofenac	87	92,6	92,6	92,6
	1 diclofenac	7	7,4	7,4	100,0
	Gesamt	94	100,0	100,0	

Ibuprofen

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no ibuprofen	80	85,1	85,1	85,1
	1 ibuprofen	14	14,9	14,9	100,0
	Gesamt	94	100,0	100,0	

Paracetamol

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Paracetamol	53	56,4	56,4	56,4
	1 Paracetamol	41	43,6	43,6	100,0
	Gesamt	94	100,0	100,0	

other analgesics

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no other Analgesics	91	96,8	96,8	96,8
	1 other Analgesics	3	3,2	3,2	100,0
	Gesamt	94	100,0	100,0	

Amodiaquine

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Amodiaquine	88	93,6	93,6	93,6
	1 Amodiaquine	6	6,4	6,4	100,0
	Gesamt	94	100,0	100,0	

Artemisinin and its derivates

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente

Gültig	0 no Artemisinin	68	72,3	72,3	72,3
	1 Artemisinin	26	27,7	27,7	100,0
	Gesamt	94	100,0	100,0	

Chloroquine

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Chloroquine	92	97,9	97,9	97,9
	1 Chloroquine	2	2,1	2,1	100,0
	Gesamt	94	100,0	100,0	

Sulfadoxine/ pyrimethamine

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Sullfadoxin/pyrethamin	87	92,6	92,6	92,6
	1 Sulfadoxin/pyrethamin	7	7,4	7,4	100,0
	Gesamt	94	100,0	100,0	

other antimalarials

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no other Antimalarials	88	93,6	93,6	93,6
	1 other Antimalarials	6	6,4	6,4	100,0
	Gesamt	94	100,0	100,0	

Amoxicillin

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Amoxicillin	88	93,6	93,6	93,6
	1 Amoxicillin	6	6,4	6,4	100,0
	Gesamt	94	100,0	100,0	

Chloramphenicol

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Chloramphenicol	93	98,9	98,9	98,9
	1 Chloramphenicol	1	1,1	1,1	100,0
	Gesamt	94	100,0	100,0	

Ciprofloxacin

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Ciprofloxacin	92	97,9	97,9	97,9
	1 Ciprofloxacin	2	2,1	2,1	100,0
	Gesamt	94	100,0	100,0	

Metronidazol

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no Metronidazole	90	95,7	95,7	95,7
	1 Metronidazole	4	4,3	4,3	100,0
	Gesamt	94	100,0	100,0	

other Antibiotics

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no other Antibiotics	92	97,9	97,9	97,9
	1 other Antibiotics	2	2,1	2,1	100,0
	Gesamt	94	100,0	100,0	

Antifungals

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0	87	92,6	92,6	92,6
	1 Clotrimazole	4	4,3	4,3	96,8
	2 Gentamicin	1	1,1	1,1	97,9
	4 others	2	2,1	2,1	100,0
	Gesamt	94	100,0	100,0	

Antihelminthics

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0	90	95,7	95,7	95,7
	1 Mebendazol	3	3,2	3,2	98,9
	2 Albendazole	1	1,1	1,1	100,0
	Gesamt	94	100,0	100,0	

Antitussiva

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente

Gültig	0	92	97,9	97,9	97,9
	1 Diphenyramine	2	2,1	2,1	100,0
	Gesamt	94	100,0	100,0	

Antihistamins

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0	86	91,5	91,5	91,5
	1 Chlorphenamin	6	6,4	6,4	97,9
	2 Cetrizide	1	1,1	1,1	98,9
	3 others	1	1,1	1,1	100,0
	Gesamt	94	100,0	100,0	

Antidiarrhoels

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0	91	96,8	96,8	96,8
	1 Loperamide	2	2,1	2,1	98,9
	2 Secniazole	1	1,1	1,1	100,0
	Gesamt	94	100,0	100,0	

Laxantives

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no laxantive	93	98,9	98,9	98,9
	1 Bisacodyl	1	1,1	1,1	100,0
	Gesamt	94	100,0	100,0	

Contraceptives

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0	92	97,9	97,9	97,9
	1 Injection	1	1,1	1,1	98,9
	2 Implantat	1	1,1	1,1	100,0
	Gesamt	94	100,0	100,0	

Herbal medicine

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no use of herbals	72	76,6	76,6	76,6
	1 use of herbals	22	23,4	23,4	100,0
	Gesamt	94	100,0	100,0	

Dietry supplement

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no use of diatry supplements	67	71,3	71,3	71,3
	1 use of diatry supplements	27	28,7	28,7	100,0
	Gesamt	94	100,0	100,0	

Other substances

		Häufigkeit	Prozent	Gültige Prozente	Kumulierte Prozente
Gültig	0 no use of other substances	62	66,0	66,0	66,0
	1 use of other substances	32	34,0	34,0	100,0
	Gesamt	94	100,0	100,0	

Multiple responses in the interviews at Valley View University

```
Group $Antibiotics  Selecton of Antibiotics
     (Value tabulated = 1)

                                                                  Pct of
Pct of
Dichotomy label                          Name       Count  Responses
Cases

Amoxicillin                              V7a1           6     40,0
50,0
Chloramphenicol                          V7a2           1      6,7
8,3
Ciprofloxacin                              V7a3           2     13,3
16,7
Metronidazol                             V7a4           4     26,7
33,3
other Antibiotics                        V7a5           2     13,3
16,7
                                                    -------    -----
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                                 Total responses       15    100,0
125,0

82 missing cases; 12 valid cases
_


Group $analgesics Choice of painkillers
     (Value tabulated = 1)

                                                                  Pct of
Pct of
Dichotomy label                          Name       Count Responses
Cases

ASS                                      V5a1           9     12,2
18,0
Diclofenac                               V5a2           7      9,5
14,0
Ibuprofen                                V5a3          14     18,9
28,0
Paracetamol                              V5a4          41     55,4
82,0
Other Analgesics                         V5a5           3      4,1
6,0
                                                    -------    -----
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                                 Total responses       74    100,0
148,0

44 missing cases; 50 valid cases
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Group $disease diseases
     (Value tabulated = 1)
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Dichotomy label	Name	Count	Pct of Responses	Pct of Cases
Malaria	V4a1	55	28,8	61,8
Infections	V4a2	22	11,5	24,7
Skin diseases	V4a3	7	3,7	7,9
Diarrhoeal Diseases	V4a4	7	3,7	7,9
Acute Eye Infection	V4a6	3	1,6	3,4
Rheuma	V4a8	16	8,4	18,0
Anaemia	V4a9	10	5,2	11,2
Worm Infestations	V4a10	5	2,6	5,6
Pain	V4a11	31	16,2	34,8
Others	V4a12	35	18,3	39,3
Total responses		191	100,0	214,6

5 missing cases; 89 valid cases

Group $antimalarials Choice of Antimalarials
(Value tabulated = 1)

Dichotomy label	Name	Count	Pct of Responses	Pct of Cases
Amodiaquine	V6a1	6	12,8	16,2
Artemisinin and its derivates	V6a2	26	55,3	70,3
Chloroquine	V6a3	2	4,3	5,4
Sulfadoxine/pyrimethamine	V6a4	7	14,9	18,9
Other Antimalarials	V6a5	6	12,8	16,2
Total responses		47	100,0	127,0

57 missing cases; 37 valid cases