Is the Agricultural Utilisation of Treated Urine and Faeces recommendable?

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Keywords: Dry Toilet, Urine, Fertiliser, Pharmaceutical Residues, Earth worms, Parasites.

ABSTRACT

One big advantage of source control sanitation, like dry sanitation, is the possibility of fertiliser re-utilisation in agriculture. Due to limited fossil resources of phosphate this is needed to aliment people in the future. The utilisation of treated faecal matter and urine can help communities with limited economical resources to produce food more efficiently. Beside the ecological, economical and social benefits, there are remaining some risks. This paper presents result of accumulation of pharmaceutical residues in plants fertilised with urine and of an "earth worm avoidance response test" on different media produced in resources orientated sanitation.

INTRODUCTION

The resulting material from dry sanitation has a great potential to substitute mineral fertiliser in agriculture and to enrich soil with organic matter. The great advantage for units with urine diversion is the separation of pathogens and most of the parasites from the fertiliser substances. But a major part of the pharmaceutical residues and in particular water soluble substances are excreted via urine. Many of those do not show good biodegradability. Therefore, a database was set up with data from literature to analyse the behaviour of pharmaceutics in urine and the environment (www.tuhh.de/aww/pharma/) [1,2] and greenhouse experiment with rye grass[1] were conducted [3].

The appearance of earth worm in the fertile top soil is considered favourable for the plant growth and health and is an indicator for a healthy soil environment. The reduction of earth worms due to human activities like manuring or ploughing is considered as unfavourable. To study the behaviour of earth worms in the presence of fertiliser product from resources orientated sanitation, an experiment was set up to investigate the preferences and avoidances of earth worms regarding these fertilisers. Different commercial mineral fertilisers as well as fertilisers from urine, blackwater and dry toilet matter were compared.

Moreover, many developing countries are suffering from a lack of health services, awareness and educational possibilities, beside other elementary things like food, houses and adequate

[1] The greenhouse experiments were conducted in cooperation with Joachim Clemens, Department Plant Nutrition, INRES, University of Bonn, 53115 Bonn, Germany

income. For this reason many organisations are promoting dry toilet or other “ecosan” systems to reduce these lacks. This is thought to be very positive, but the fact that many people are seriously affected by parasites is easyly underestimated due to the lack of experience in Northern countries. To avoid the spread of parasites due to the use of faecal matter form dry toilets, a proper qualified treatment is required.

METHODS

To obtain an overview of the relevance of pharmaceutical residues in water bodies and excreta, data from literature and own data where collected and fed into a database [4]. This allowed to receive statistical data for the active agents if sufficient information could be collected. Due to the web interface [5] the public has access to the database as well. For the pot experiments three substances were selected: Carbamazepine CZ (anti epileptic), Ibuprofen IBU (analgesic) and 17α-Ethinylestradiol EE (contraceptive) that were found in human urine. Finally for the green house experiments the pots with rye grass were fertilised with spiked male urine. The concentration range of the pharmaceuticals was chosen as expected values in Middle Europe urine as well as enhanced by the factor 10 (EE by factor of 40).

The main idea is, to implement an easy applicable bio-test for fertilisers from urine and faeces. As organisms Earth worms (*Eisenia foetida)* were selected as organisms. Four buckets were placed, filled with garden soil and covered with soil in a way that all buckets were connected with each other via soil. 1 g N from urine, ammonia solution or mineral fertiliser spiked with 10 mg 10,11-Dihydrocarbamazepine, 50 mg Dicolfenac sodiumsalt and 100 mg 2-(4-Chlorophenoxy)-2-methylpropionic acid dissolved in 500 ml water was applied to each bucket. This amount corresponds with the normal fertiliser dose of 150 kg N /ha. As reference a mineral N,P,K fertiliser was chosen. 50 to 100 earth worms were placed in the mid between the four buckets. 24h later the worms were counted in every bucket. To become statistical sure, every experiment was repeated 9 to 10 times. Figure 1 shows the experimental set- up and a photograph respectively.

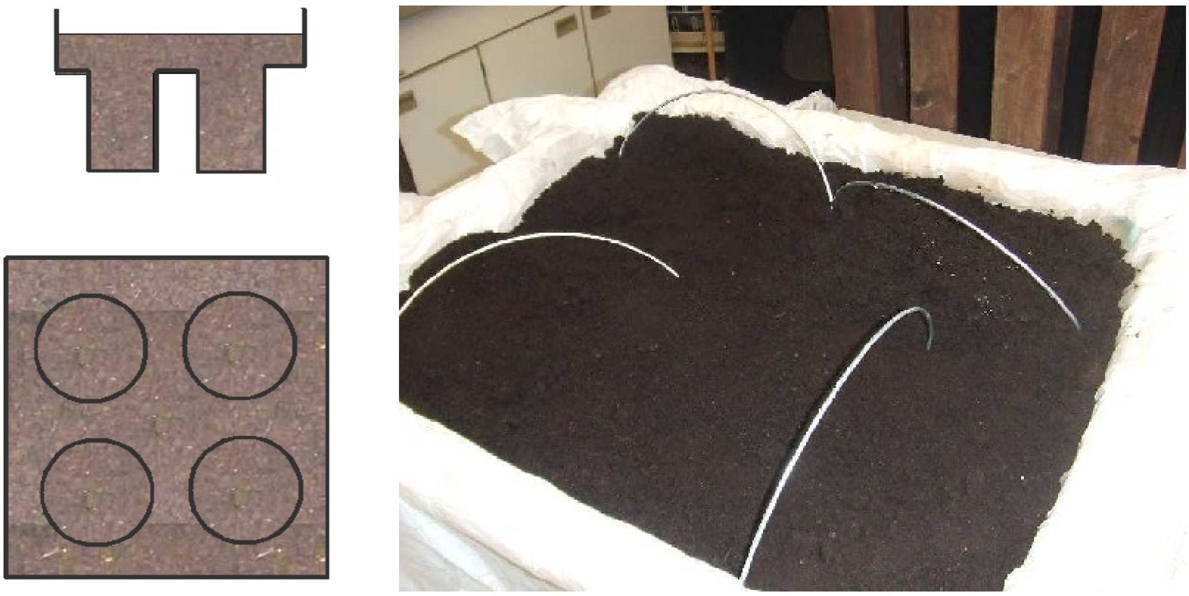

Figure 1. Experimental set-up of the “Earth-worm Avoidance Response Test”

RESULTS

Querying the above mentioned database for pharmaceuticals in the wastewater type "yellowwater" (urine) 17 components were found manifold. This seems to be little, but the main focus of analyses of pharmaceutical was set on surface water (drinking water supply) and the effluents of wastewater treatment plants. The result of the query is given in Figure 2. The three pharmaceutical chosen for the pot tests are included and marked orange. The analysis of pharmaceuticals in soil and plant parts is quite tricky. The limits of quantification (LOQ) of the TUHH central Lab for the three pharmaceutical are given in Table 1. The concentration of 17 α Ethinylestradiol is two low for the disposable analytic no effects could be determined.

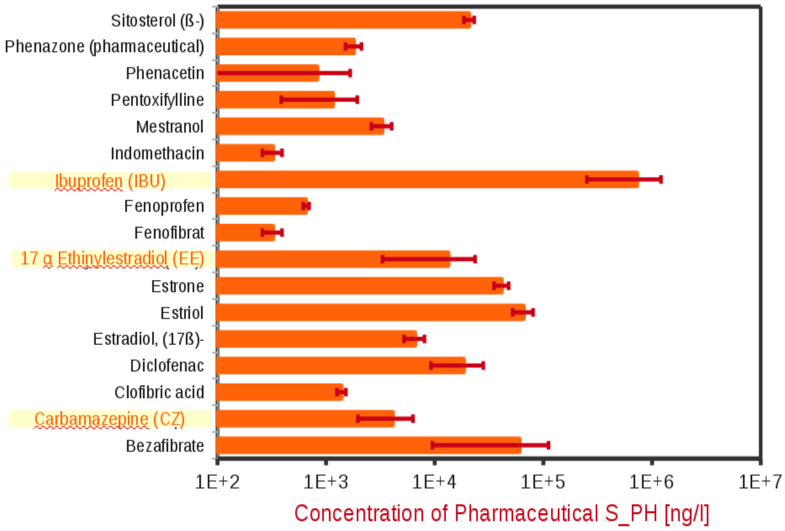

Figure 2. Concentration of pharmaceutical substances in German urine obtain from a query of the database with values from literature (www.tuhh.de/aww/pharma).

Table 1. Limit of Quantification at TUHH Central Lab [3]

	LOQ in soil ($\mu g\ kg^{-1}$ DM)	LOQ in roots ($\mu g\ kg^{-1}$ DM)	LOQ in leaves ($\mu g\ kg^{-1}$ DM)
Ibuprofene	2	30	-
17 α Ethinylestradiol	2	-	-
Carbamazepine	0.6	20	75

Even with the 10 fold dosage of natural concentrations in urine, no effect on the biomass production could be observed. After the growth period of 92 days, only carbamazepine could be found in the soil of the pots. Because of the difficult matrix only carbamazipine could be detected and quantified in the soil and in the plant parts as well. About 50% of the carbamazepine could be found after 92 d in soil. In Figure 3 the concentration of carbamazepine (CZ) in soil, root and leavers of pot tests with rye grass applied 10 fold than natural concentration level sole and in combination with other pharmaceuticals after 92 days are given. Every test was conducted three fold and the standard deviations are given additionally. It is clearly to make out that carbamazepine is enriched in the root at factor 15 and in the leaves at factor 350 in relation to the soil concentration. The combination with other pharmaceutical substances remains unclear due to the deviation of the measured concentrations, but the general evidence of the enrichment in the plant is not effected by this. Ibuprofene was not found in soil after 92 day, supposedly because ibuprofene is degraded in the soil during this period.

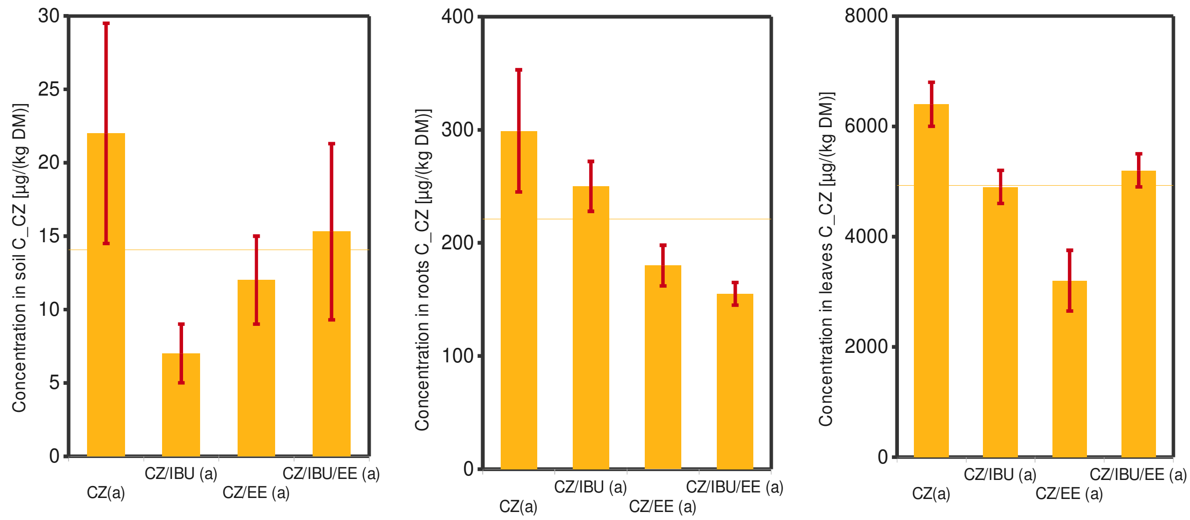

Figure 3. Concentration of carbamazepine (CZ) in soil, root and leavers of pot tests with rye grass applied 10 fold than natural concentration level sole and in combination with other pharmaceuticals (Data from [3]).

The determination of toxic or other negative effects on plants can not be deduced from the existence of pharmaceuticals in plants. Therefore, an earth worm avoidance response test, as an easy an cheap method to determine effect on earth organism. *Eisenia foetida* was selected as indicator organism because it is wildly spread in Europe and easyly to raise.

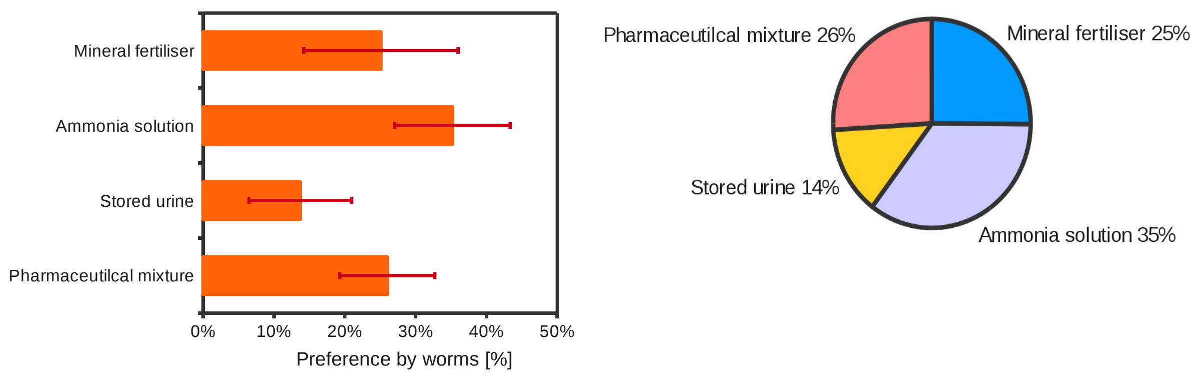

Figure 4. Result of the first run with 10 repetitions of the worm avoidance response test.

Firgure 4 shows the results of the first run with 10 repetitions of the earth-worm avoidance response test. In the 4 bins mineral fertiliser was tested as reference with ammonia solution, to see if the ammonia is unconfortable for earth worm, mineral fertiliser spike with the artificial pharmaceutical mixture described above and stored urine. The deviation, given as interval of confidence at 95%, is flashy big, but in any case the ammonia solution is most popular to earth worms, while urine is most unpopular. Only half of the amount of earth worm were found in the urine fertilised compartment. The pharmaceutical did not have an effect on *Eisenia foetida.*

Due to the good acceptance of ammonia solution, sodium chloride was added for the second run, to see if the high salt concentration is the reason for the poor acceptance of urine by earth worm. Additionally beside urine, biological treated urine with nitrification was used for the test (Figure 5). In this case the compartment, fertilised with the ammonia solution, indicated the best acceptance for earth worm. The hight salt content was not the reason why worms avoid a compartment as assumed after the first run. Differently to the first run (10 repetitions), urine is accepted equal to mineral fertiliser in the second run (9 repetitions), while biological treated urine, with Nitrate as N-Source was unpopular for the worms.

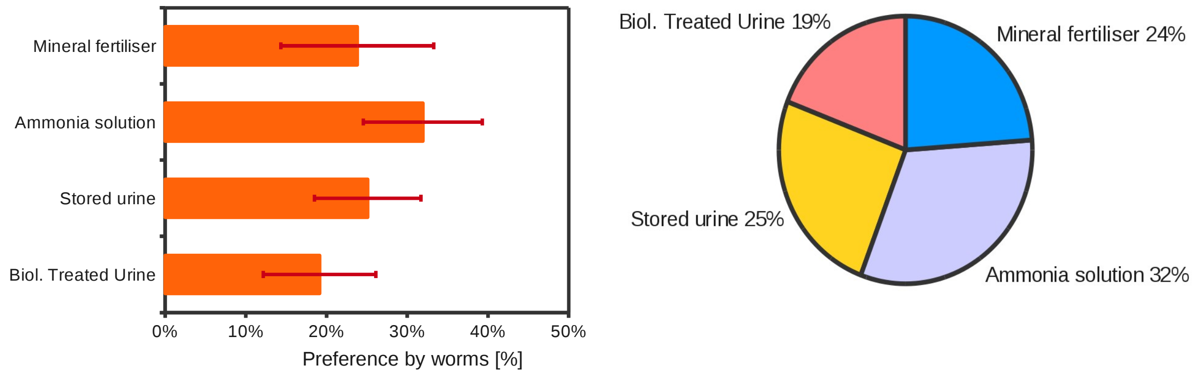

Figure 5. Result of the second run with 9 repetitions of the worm avoidance response test.

The two run were subsumed in Figure 6. The results with mineral fertiliser and ammonia solution show a good conformity while the tests with stored urine differed widely.

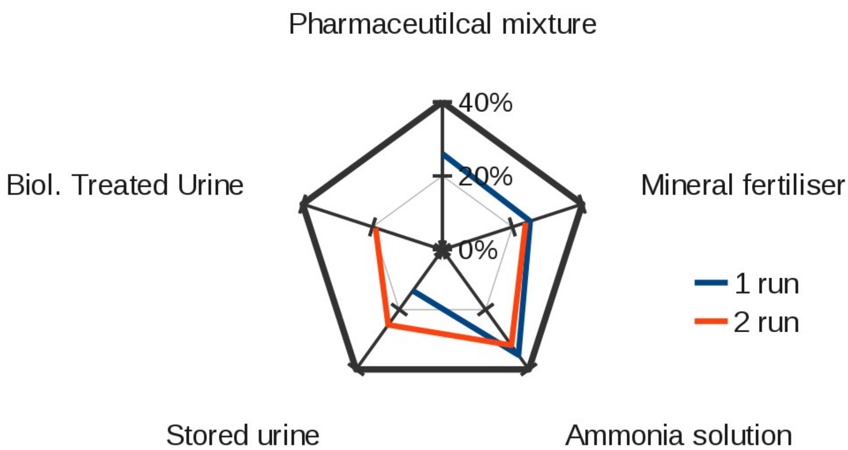

Figure 6. Radar plot of the two run for the worm avoidance response test

DISCUSSION AND CONCLUSIONS

Querying the database for the appearance of pharmaceutical in plants many data could be found. But in general veterinary pharmaceuticals could be found. It is clear that biodegadability is the best option to prevent accumulation of pharmaceutics in plants. But it is not very likely that future pharmaceutics substances are designed more biodegradable. Therefore, more information about he behaviour of pharmaceutics is required to ensure the safety utilisation of urine as fertiliser supplement. The example in this study show an accumulation of carbamazepine by a factor of nearly 400 in the leaves, i. e. over 30% of the applied carbamazipine was found in the leaves of the rye grass. But an effect for consumers cannot be deduct at the moment.

The first test runs of the earth worm avoidance response test show a little effect on urine. Stored urine, treated and untreated is not as popular for the earth worm *Eisenia foetida* as ammonia solution with or without sodium chloride as well as mineral fertiliser. This result differs from Muskolus [6] observations, in which no worm were found 24 h after fertilising with urine. But the avoidance of worms do not mean that urine is less valuable as fertiliser than other products. These tests were performed with a soil for horticulture that is rich in organics. Due to good adsorption capacities the effect of unpleasant components in urine do not obtrude explicitly. Therefore, additional test with soil that is poor in organics have to be carried out.

ACKNOWLEDGEMENTS

The author like to thank the DBU (German Federal Foundation for the Environment), the Linz AG and the TUHH, especially the central lab (Dr. Reich and Mrs. Engel) for supporting this study. The research related to pharmaceutical substances was accomplished in the 6th EU framework project 'SWITCH'. The plant trials were conducted in cooperation with Dr. Joachim Clemens, INRES, University of Bonn.

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