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**SUSTAINING WATER AND SANITATION SERVICES FOR
ALL IN A FAST CHANGING WORLD**

Disposal of medicines and impact on water resources

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Pharmaceuticals, used for prevention, diagnosis and treatment of medical conditions, play a crucial role in healthcare delivery. Although prescribers, dispensers and users of pharmaceuticals envisage certain outcomes, pharmaceuticals end up having unintended effects both in the consumer and in the environment if the pharmaceuticals end up in the environment. One very significant way in which pharmaceuticals enter the environment is by disposal of unused, unwanted or expired medicines. A case study of the Disposal of Unused Medicines Project was undertaken and the information gathered was analysed to assess the effectiveness of disposal methods in place, discuss identified disposal patterns and estimate the extent to which medicines are disposed indiscriminately and in unregulated circumstances.

Introduction

The role pharmaceuticals play in healthcare delivery means they are consumed the world over in very significant quantities. Their use in preventing, diagnosing, treating and managing various health conditions envisage certain outcomes. In their use, however, certain effects have been detected over the years which are not the desired or expected. Some of these effects have been identified in various environmental media as well as in organisms associated directly or indirectly with these media.

Although research has been conducted across the globe to look into the presence, persistence and effects of pharmaceuticals in the environment, very little has been done in that regard in Africa in general and Ghana in particular. There is the need to look into how pharmaceuticals get introduced into these environmental media and assess the potential and actual effects of these pharmaceuticals on the water sources and on ecosystems which are exposed to these pharmaceuticals.

Pharmaceuticals in water sources

Entry into the environment

Pharmaceuticals have been identified as being present in various environmental media (Boxall A. , 2004) (Velo, 2008). They enter environmental media via various routes. Pharmaceuticals may get into environmental media as elimination products after human and veterinary use, as unchanged compounds or active metabolite – product of metabolism which still have some effects on biological systems. They may also get into the environment from the pharmaceutical industry as active pharmaceutical ingredients (APIs) or the products of washing during production. There may be instances where these products go through waste water treatment plants (WWTPs). These plants are however not designed to take out the pharmaceuticals from the water being treated. The pharmaceuticals are therefore discharged into the receiving waters. Fig. 1 shows a schematic diagram of the ways in which pharmaceuticals move in and out of water sources (Esseku, 2014):

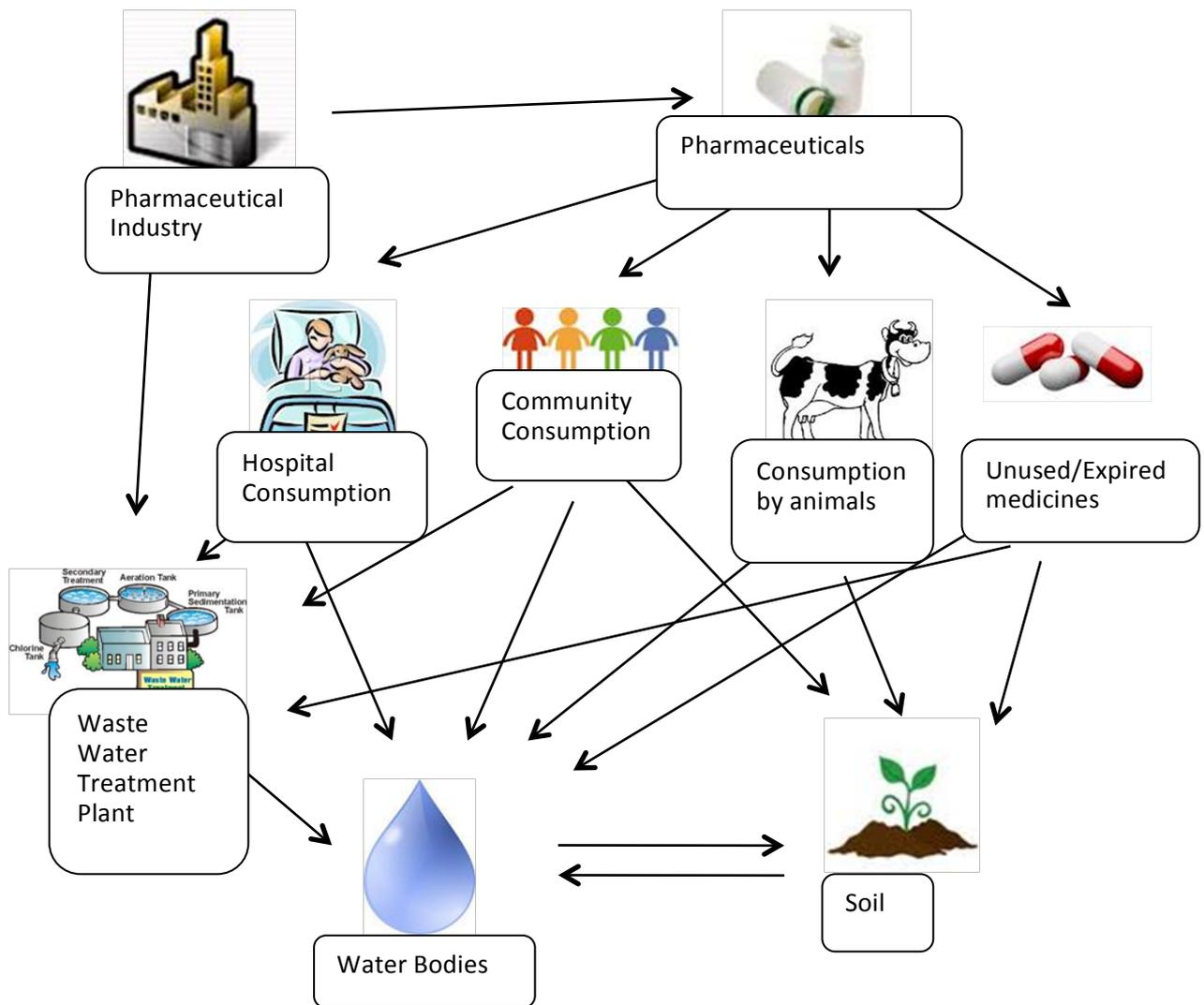


Figure 1. WEDC – Schematic Diagram of Movement of Pharmaceuticals

Source: WEDC – Esseku (2014)

Persistence

Pharmaceuticals in the environment undergo various attenuation processes such as photo-degradation, dilution, absorption by solids and aerobic and anaerobic breakdown (Sakrabani & Boxall, 2007) (Snyder, et al.). However, some pharmaceuticals and chemicals tend to persist in the environment in their original form or as metabolites. Nilsen *et al* test sediment samples collected from the Columbia River, Willamette River, the Tualatin River and several small urban creeks for the presence of pharmaceuticals. Glassmeyer *et al* in investigating the use of chemical analytes as waste water tracers found pharmaceuticals and other chemicals in the effluent of waste water treatment plants. In another research, a veterinary pharmaceutical was traced through lagoons, ground water and runoff on the farms under investigation (Watanabe, Harter, & Bergamaschi, 2008). Davis *et al* (2006) also investigate the presence of pharmaceuticals in the soil and runoff from land treated with mixture of pharmaceuticals. **Error! Reference source not found.** shows a summary of the results of these studies.

Table 1. Style: WEDC – Summary of results of investigations of various media for persisting pharmaceuticals			
Research Work	Medium Investigated	Location of Medium	Status of Pharmaceuticals/Chemicals
Nilsen et al.	River bodies and tributaries	Columbia River, USA	20 pharmaceuticals detected
Glassmeyer et al.	Waste water treatment effluent	WWTPs, USA	78 chemicals detected
Watanabe, Harter, & Bergamaschi, 2008	Flush lanes, lagoons, ground water	California, USA	1 veterinary pharmaceutical
Davis, Truman, Kim, Ascough II, & Carlson, 2006	Runoff, exposed soil	Colorado, USA	All pharmaceuticals in runoff and soil

Effects

As interest in pharmaceuticals in environmental media grows there is a corresponding desire to investigate the effects of these pharmaceuticals on organisms that depend on these media for survival. Wu et al (2011) have reviewed publications of research into how some agriculturally relevant plants take up pharmaceuticals from hydroponic and soil systems (Wu, Spongberg, & Witter, 2011). Guillette Jr. et al (2000) have looked into how endocrine disrupting contaminants (EDCs) have affected various physiological characteristics of the American alligator in fresh water bodies in Florida (Guillette, Pickford, Crain, Rooney, & Percival, 1996b). Other effects of pharmaceuticals in the environment that have been identified include the feminization of fish on exposure to human female hormones and the near collapse of south east Asian vulture populations as a result of exposure to the anti-inflammatory agent diclofenac (Roach, 2004) (Randolph, 2011).

Disposal of medicines – good practice

With increase in knowledge of some of the potential and actual effects of medications on the environment, some countries have come out with guidelines on how to dispose of unused, unwanted and expired medicines. The Government of Canada (2014) and the United States Environmental Protection Agency (US EPA) (2011) and Food and Drug Administration (US FDA) (2014) have issued such guidelines. All these guidelines recognize the need to avoid unnecessary exposure of environmental media to human and veterinary medicines. The recommended method of disposal is the use to take back schemes and events which allow the controlled disposal of these medicines. Where such schemes are not available, there are specific steps to taken for the proper disposal of medicines with household trash. In some specific instances, where there is the possibility of poisoning with some specific medicines, there are recommended steps for the flushing of these medicines down sinks or toilets (U.S. FDA, 2014).

The case study

The method used for the study is qualitative in nature. Qualitative research allows in-depth understanding into a particular subject matter. One case was studied and qualitative interview questions were designed for effective discussion on various aspects of the project under discussion. The semi-structured interviews allow open discussions on identified issues and explaining aspects of the subject of discussion as the need arises. The interviews were semi-structured in nature and were targeted at key informants. Key informant interviews allow information to be gathered from persons with particular insight into the subject matter under discussion. In this study, the key informants were persons who are directly involved in the DUMP project as well of officials involved in the disposal of chemicals.

The Cocoa Clinic and the Food and Drugs Authority are involved in the Disposal of Unused Medicines Project (DUMP) in Accra. The role of the Clinic in this project is to receive unused medicines from their clients and other members of the general public. These medicines are sorted out periodically and disposed

of under the supervision of the Food and Drugs Authority. The role of the FDA is to ensure the proper and effective disposal of the unused medicines received under the project.

This project is novel and at the moment is limited to the Cocoa Clinic in terms of collection and receipt of unused medicines. To investigate the disposal of unused medications, the method of study used is that of a case study. The bulk of the information gathered was by interviews with personnel of Cocoa Clinic, Food and Drugs Authority who are involved in the DUMP project and personnel from Environmental Protection Agency involved in the disposal of chemicals and industrial waste. There was also the need to review legislative provisions that relate to the disposal of medicines, industrial waste and other chemicals.

Disposal of pharmaceuticals

There is in place in Ghana a legislative framework governing the disposal of medicines. This framework provides for the disposal of unwholesome products seized from premises where they are manufactured, stored, prepared or sold. The legal provisions, however, do not cover the disposal of unused medicines or medicines in the custody of individuals or private organizations which cannot be classified as adulterated or contaminated.

The process of disposal is triggered when the individual or organization seeking to dispose of pharmaceuticals writes officially to the FDA about their intention. The FDA conducts an audit of the pharmaceuticals and the quantities to be disposed of and the ascertained quantities inform the fees to be paid by the individual or organization. A date is then set for disposal. On the set date, the individual or organization provides transportation for the pharmaceuticals to the disposal site. The FDA accompanies the pharmaceuticals to the disposal site and supervises the disposal.

The FDA disposes of pharmaceuticals by four (4) means

- Crushing and burying. Here, the products are placed in the identified excavated spot, crushed and the pit covered over with earth. This method is used for solid dosage forms.
- Burning. The products are sent to the disposal site, doused with fuel and set on fire. This method is used for solid dosage forms.
- Disposal into municipal drains. Here, liquid formulations are emptied down municipal drains. Solid dosage forms are not handled in this manner.
- Incineration. This is used for vaccines, oncogenic medicines and steroids.

The disposal sites are not owned by the FDA. This means that the organization or individual will have to pay for the management and maintenance of the site.

The DUMP project was initiated by the Cocoa Clinic Pharmacy in response to the need to provide options to clients with respect to the disposal of their unused medicines. The project was initiated when, during counseling, it became clear that some clients had medicines from previous visits which they had not consumed. The clients were educated on some of the dangers of keeping unused medicines and encouraged to return their unused medicines to receptacles provided in the facility. Receptacles are places in waiting areas and other open places to allow clients to drop in their unused medications anytime they wish to. The medicines are sorted out according to their pharmacological actions and weighed before being sent for disposal under the supervision of the FDA. Since the inception of this project, significant quantities of medicines have been received for subsequent disposal.

Cocoa Clinic serves only a small proportion of the population, being one of two hundred and fifty-two (252) clinics in the Greater Accra Region. Although some of these clinic may be smaller and others bigger, the values obtained from Cocoa Clinic will be used as representative of what is available among members of the public who attend clinics. Figure 3 shows typical values of some of the medications that have been received and the projected values of what could be available from other clinics in the region. It must be noted that these figures do not include figures from polyclinics and referral hospitals.

Class of medicine	Percentage	Weight (kg)	Projections (kg)
Antihypertensive agents	21	15.54	3916
Antibiotics	18	13.32	3357
NSAIDS	18	13.32	3357
Steroids	8	5.92	1492
Anti-malarial agents	6	4.44	1119
Haematinics	6	4.44	1119
Anti-diabetic agents	5	3,7	932

Potential impact of poor disposal of medicines

There is a general understanding among the regulatory authorities that poor disposal of pharmaceuticals will have negative implications for both the environment and communities living close by:

- Contamination of ground water where no consideration is taken of the water table in the process of burying unused medicines.
- Fumes from open burning of trash which contains medicines could affect human health.
- Medicines dumped into drains could end up in water bodies and become harmful to aquatic organism.

This understanding has led to burning being carried out in sites which have been identified as being significantly removed from human populations. The dump sites are also areas which have been identified as having low water tables to reduce the possibility of contamination to the barest minimum.. there are however challenges with these measures:

- Fumes from burning could affect nearby vegetation or get dissolved in rain or fog and get into surface water sources. Aquatic animals such as fish exposed to even small doses of pharmaceuticals have been found to be able to concentrate them in some tissues (Shield, 2011).
- The method of dumping liquid formulations directly into municipal drains means that medicines will enter surface water sources and contaminate them.
- Pharmaceuticals have been identified in groundwater samples 300m from landfills which had been decommissioned 21 years earlier (Shield, 2011). These findings mean that no matter how low the water table of the dumping site, where dumping is done in un-engineered sites, pharmaceuticals which persist will, in time, get to groundwater sources.

The methods that are currently in place do not, however, comply with international good practice. The method of flushing is not restricted to very few products and is a method of choice for liquid medications. The take back method is not currently widespread, making the majority of disposal unregulated and indiscriminate.

Conclusion

Although there is a legal framework for the disposal of pharmaceuticals, the provisions do not sufficiently cover unused medicines. Thus unused medicines are generally disposed of in an unregulated manner. The methods in place for the disposal of medicines, although premised on environmental considerations, do not provide sufficient protection to the environment in general or water sources in particular.

The DUMP project, instituted to take back unused medicines from clients, shows a stark need to mop up excess pharmaceuticals present among members of the public. The methods available for the regulated disposal of unused medicines do not provide sufficient protection for the environment. Unregulated disposal of pharmaceuticals result in the exposure of various environmental media to pharmaceuticals.

The following recommendations arise from the study:

- Review of the legal framework governing the disposal of pharmaceuticals.
- Institution of policies to mop up excess medicines with members of the public.
- Further research into the types of pharmaceuticals that are currently present and persisting the various environmental media, their effects and how they affect quality of life.

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