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SUSTAINABLE ENVIRONMENTAL SANITATION AND WATER SERVICES

# A Solid Life-Cycle Approach to Control. The Content of Sludge in Waste Water

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Effective wastewater treatment remains a priority on the wish lists of many Indian environmentalists. But this wish remains unfulfilled as the water bodies downstream from several major Indian cities (such as Delhi, Mumbai, Kolkatta, Chennai & Hyderabad) continue to receive untreated sewage. The ingredients of this noxious soup include human waste along with other unsavoury items flushed down toilets and washed down drains, such as pharmaceutical products. They also include effluents from business and industrial operations and, in many cases where sanitary and storm sewers are combined, runoff from urban areas. The latter two sources may contribute heavy metals, pesticides (which includes a whole host of constituent compounds), polyaromatic hydrocarbons (PAHs), and other organic compounds.

The best bet to reduce the environmental burden of the sewage "life-cycle" as well as environmental impacts of land application is a combination of upstream control over what is allowed to become part of the sewage sludge with downstream best practices to manage final disposition as a land-applied "biosolid". Life-cycle inventories rely on a simple accounting of physical units or, as engineers refer to them, "mass balance". For instance, when dental amalgams containing mercury are used, the bulk of the mercury stays within the amalgam (the filling), a very small portion is ingested by the patient (some is passed), and the remainder is washed down the drain when the patient washes their mouth out. The portion passed and the portion washed down the drain end up at the sewage treatment plant of which some remains in the sewage sludge and the balance is discharged to the receiving water body. With a heavy-metals management program at the sewage plant being prohibitively expensive to build and operate (and according to experts in the field, technologically unproven), the simple solution becomes pollution prevention at the dentist's office. That is, the substitution of the use of mercury based dental amalgams with the use of composite materials. Irrespective of whatever is subjectively considered "acceptable" for land application, the ongoing reduction of metals in sewer loadings can only increase public confidence in the practice of regulated land application of biosolids. Of even greater importance, reducing the loadings of these constituents to sewers means reducing the portion going to receiving water bodies. When heavy rains occur the system overflows, sending raw sewage and urban runoff into receiving water bodies. Urban runoff is comprised of rainwater and a host of chemicals that wash off of parking lots, industrial parks and roads. These include wearing automobile parts (chromium, cadmium, copper, lead, and arsenic), automotive emissions (PAHs, used motor oil, spilled diesel and coolant), pesticides and herbicides, and solvents and coatings (from painting and metal processing). Having taken these upstream steps, the resulting sewage sludge is freer of many of the heavy metals and organic compounds than it would have been otherwise. Nevertheless it remains noxious. Untreated human waste contains bacteria, viruses and other pathogens that must be treated fully to render the resulting biosolid virtually pathogen inert.

## Introduction

I a typical metropolitan region, an abandoned canal ditch is used as a chemical dumping site for over thirty years, then closed. Several years afterward, homes are constructed adjacent to the site and an elementary school is opened. Two decades later, residents complain of noxious basement odors. It becomes evident that the serious health hazard exists, the result of chemical waste disposal begun more than half century earlier. The current high level of understanding of the mechanisms applied to waste water treatment has resulted from the collaboration of microbiologists, biochemists, sanitary engineers and chemical engineers. This collaboration has led to the construction of many technically advanced and highly successful sewage - treatment plants. These plants generally use aerobic processes for the degradation and mineralization of the organic compounds in the sewage and anerobic processes for the stabilization and mineralization of sludges, although, and conversley, anaerobic systems are also used for liquid waste water treatment, particularly for the treatment of strong organic industrial waste waters, and sludges are stabilized aerobically.

Any change in the composition of waste, which often includes polluting materials like heavy metals or toxic chemicals, may take necessary development of new, more efficient treatment processes in respect of conversion rates and separation of undesirable components. Biotechnology, because of the selectivity of its processes, can play a substantial role in solving the environmental problems caused by waste. Classically wastes have been disposed of in ways that appeared to be the cheapest and the least repulsive to the public. Few people believed that serious consequences could ensure, even if the method being used was ultimately found to be inadequate. In most cases, the effects on the environment of the constituents of the wastes were not known. Furthermore, technology was not available that would make treating the wastes physically of financially possible for most industries. Very often the method of disposal simply involved land application, in one form or another.

Land disposal of hazardous wastes is a technique used by all sectors of the population. With the expansion of industry and the migration of a larger portion of the population to suburban and rural areas, the ability of land to absorb such wastes with no apparent consequences has diminished. The most catastrophic environmental impact has been the widespread contamination of the nation's ground water supplies. Because a broad segment of the population depends upon this resource, the potential consequences are obviously grave. The basic physical problem with land disposal of hazardous waste systems from the movement of water, originating as precipitation into and through the disposal site. The dissolution of waste material results in contaminants being transported from the waste site to larger regions of the soil zone and, too often, to an underlying aquifer.

**Water Recovery and Reuse**

The recent discoveries of how to increase the efficiency of microbial and biochemical conversions offer new opportunities for waste treatment. Traditionally biological waste treatment has been used to render waste inoffensive and non-pathogenic. It now includes the conservation of resources and by-product recovery. Unfortunately, recovery of materials from waste is rarely the first – approach to waste treatment. This is partly because of the complex heterogeneous nature of the wastes, but the poor value of many of the recovered by-products is also an important factor. Thus, with the exception of some simple processes for water and fertilizer recovery, if waste water is not suitably treated before it is returned to the natural environment then it becomes a nuisance. Polluted water destroys aquatic life, reduces land values, can cause an offensive smell and is almost certain to be associated with disease by the general public. Treated or restored water, on the other hand, can be considered as an additional resource for reuse. In practice there is no economic method of treatment which will remove all the impurities present and water reclamation to drinking water standards is very expensive. Planned reuse of polluted water for purposes other than drinking can easily be justified economically and can produce significant savings.

**Drinking Water**

It might be desirable from health and an economic point of view to obtain raw drinking water from unplanned sources free from both natural and urban contaminants, this is becoming increasingly difficult and is virtually impossible in arid climates. Thus rivers and lakes have become aqueducts for both water supply and the disposal of wastewater. This practice is quite common and has continued for many years without any ill effects but there are potential health risks of breakdown, human error and the long-term effects of trace chemicals that may remain in the wastewater. Much has to be learned about the removal of pathogenic micro-organisms, particularly viruses. Considerable research has recently been undertaken to refine and scientifically confirm that the procedures identified by experience are safe. Recently water quality has been checked routinely by simple chemical and bacteriological tests such as total organic carbon, turbidity and coliform tests. Newer analytical tests such as mass spectrometry and high-pressure liquid chromatography can now be used to detect minute concentrations of organic materials from sewage, agricultural and industrial wastes.

**Sources for exposure to Hazardous Chemicals**

The danger to the environment is not from the production of the hazardous waste but rather from its ultimate disposal. A primary mechanism for transport of improperly discarded hazardous waste through the environment is via the movement of water through ground and surface systems. The sources may be direct or indirect, intentional or unitentional, natural or artificial. We might also classify them into the following categories.

- Biological cycles – including decay of animal and plant life, excretion of toxins, and so on.
- Domestic waste – including discharges of raw or treated waste water that contains, in addition to conventional pollutants, any of the hazardous compounds normally used in residential life and discharged via our sewage systems.
- Industrial waste – again including raw or treated waste water discharges.
- Nonpoint sources – such as landfill leachate, septic tank leachate, and storm water runoff containing hydrocarbons, solvents, fuels, oils, heavy metals, and so on.

**Table – 1 Metals in domestic sewage sludge (mg/kg dry solids)**

| Type of sludge | Dry Solids (%) | Cd | Cr | Cu | Fe | Pb | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| Raw sludge Ex. 1 | 1.9 | 20 | 90 | 315 | 13814 | 300 | 15 | 871 |
| Raw sludge Ex. 2 | 4.9 | 20 | 42 | 169 | 6651 | 206 | 15 | 568 |
| Digested sludge | 2.7 | 20 | 403 | 605 | 19355 | 454 | 81 | 1411 |

## Estimating the fate of Hazardous Chemicals

A basic question in our evaluation of hazardous wastes in the environment is that of the implications for human health. One problem in predicting the fate of toxic substances – or of any pollutant, for that matter – is that the science dealing with environment pollution is so young, having surfaced formally only within the last two decades. The state of our knowledge, though growing daily, is limited. Unfortunately, decisions regarding regulation of environmental pollution need to be made today. When making decisions based on limited information, we must exercise caution. A common tool used to make predictions is the mathematical model, generally a series of equations that attempt to describe the characteristics and response of some physical system. Mathematical models are used in many sciences. In economics, they are used to predict trends in market activity, the occurrence of recession or productive periods, and the like. In meteorology, they are used for prediction of short – term weather conditions as well as long – term climatological changes. In the environmental sciences, mathematical models can be used to predict the transport and fate of pollutants. Such models need not be complex sets of equations, incomprehensible to the average man, although in some cases these may be necessary. The advantage of mathematical models is that they enable the scientist and engineer to integrate in a consolidated frame work all the various reactions that proceed simultaneously, affecting the concentrations of various pollutants.

## The Metal Content of Sludges

A disadvantages of sewage sludge is that it may contain appreciable concentrations of potentially toxic materials. The best-documented toxins are the heavy metals. Since the new Water Act of 1973, more rigorous consent conditions have been imposed by the water authorities on industrial discharges to sewar and in many cases the concentrations of metals in sludges has fallen by over 50 percent. Additional improvements have been brought about by the recession of old heavy industry. There is, therefore, greater potential for the reuse of sludge as a fertilizer. At present it is used on only 1.25 percent of the land used for agricultural purposes in the UK.

Most data on phytotoxicity relate to zinc, copper and nickel; their effects seem to be additive. To cater for the most sensitive crops it is assumed that copper is twice as toxic as zinc, nickel eight times as toxic and boron 150 times more toxic than zinc. Cadmium, lead and chromium cause problems for the consumer rather than having a direct effect on plant growth. Cadmium accumulates in the leaves of plants and additions are restricted to 5 kg/ha per year. Lead and chromium are less toxic since they are not taken into the edible part of the plant. Normally, totally domestic sewages have low concentrations of heavy metals, but they may contain appreciable quantities of zinc from costemics and pipe work. Table – 1 above shows the metal content of some typical waste water sludges.

## Conclusion

Waste water should be properly treated before it returns to the natural environment, or otherwise it will cause so many health hazards to the society. Treated water or restored water can be considered as a safe measure for reuse. Proper planning must be emphasized for reuse of polluted water for other than drinking purposes. The major portion of water used by the mankind is only for secondary purposes. So, justification is made economically to produce significant savings by reuse of treated water.

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