EVALUATION OF ENGINEERING PROPERTIES OF WASTE WATER TREATMENT PLANT SLUDGE FOR ITS UTILIZATION

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Abstract: With the rapid pace of industrialization and urbanization the large amount of waste water is being generated, which must be treated to prevent the environment hazardous and human health. There are number of waste water treatment plant (WWTP), which treats the waste water and produce the inevitable by products, sludge is the largest in volume. The sludge produced as residue from WWTP which must be considered under study to utilize this by-product and also to prevent the environment hazardous. The evaluation of engineering properties is presented in this paper to utilize the sludge in various fields.

Keywords: WWTP Sludge, Heavy Metals, toxicity, phytotoxicity, food chain, bio-maginfication, organic compounds

1. Introduction

Sludge is the solid material removed during the treatment of wastewaters. Waste Water Treatment Plant (WWTP) sludge is an inevitable end product of modern wastewater treatment plant. In India, a large quantity of wastewater sludge is produced annually in all the cities because of the rapid progress of urbanization and industrialization. Thus the amount of sludge generated from wastewater treatment plants has been increasing year-by-year as the sewerage service area expanded. The constituents removed during wastewater treatment include grit, screenings and sludge. Of the constituents removed by effluent treatment, sludge is by far the largest in volume, therefore its handling methods and disposal techniques are a matter of great concern.

Sludge meant the entire residue which remains after treatment of city sewage by grit chambers, bar screens and mesh screens, tanks, wells, and towers, by plain sedimentation or chemical precipitation, septic tanks, contact beds or irrigation fields. Its composition and amount depend upon:

1. The composition and volume of the sewage
2. The manner of collection
3. The method of treatment
4. The operation of the plant

2. Sludge characteristics

Most wastewater treatment processes produce a sludge which has to be disposed of. In order to treat and dispose of the sludge that is produced in a wastewater plant effectively, it is crucial to know the characteristics of the sludge that to be processed. A typical chemical composition and

properties of untreated and digested sludge is reported in Table 1.

Table 1 Typical chemical composition and properties of untreated/digested sludge (Metcalf & Eddy, 2003)

Item/sludge	Untreated primary		Digested primary		Untreated Activated
	Range	Typical	Range	Typical	range
Total dry solids (TS), %	2.0–8.0	5.0	6.0–12.0	10.0	0.83–1.16
Volatile solids (% of TS)	60–80	65	30–60	40	59–88
Grease and fats (% of TS)					
Ether soluble	6–30	—	5–20	18	—
Ether extract	7–35	—	—	—	5–12
Protein (% of TS)	20–30	25	15–20	18	32–41
Nitrogen (N, % of TS)	1.5–4	2.5	1.6–6.0	3.0	2.4–5.0
Phosphorous (P_2O_5, % of TS)	0.8–2.8	1.6	1.5–4.0	2.5	2.8–11.0
Potash (K_2O, % of TS)	0–1	0.4	0.0–3.0	1.0	0.5–0.7
Cellulose (% of TS)	8.0–15.0	10.0	8.0–15.0	10.0	—
Iron (not as sulfide)	2.0–4.0	2.5	3.0–8.0	4.0	—
Silica (SiO_2, % of TS)	15.0–20.0	—	10.0–20.0	—	—
Alkalinity (mg/l as $CaCO_3$)	500–1500	600	2500–3500		580–1100
Organic acids (mg/l)	200–2000	500	100–600	3000	1100–1700
Energy content	10,000–12500	11.000	4000–6000	200	8000-10000

Very rarely do urban sewerage systems transport only domestic sewage to treatment plants; industrial effluents and storm-water runoff from roads and other paved areas are frequently discharged into sewers. Thus sewage sludge will contain, in addition to organic waste material, traces of many pollutants used in our society. Some of these substances can be phytotoxic and some toxic to humans and/or animals so it is necessary to control the concentrations in the soil of potentially toxic elements and their rate of application to the soil.

2.1 Heavy Metals

The physical–chemical and biological processes that are involved in activated wastewater sludge treatment, sludge tends to accumulate heavy metals existing in the wastewater. Sludge generated from wastewater treatment plant contains large number of heavy metals such as zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), lead (Pb), mercury (Hg) and chromium (Cr) which restricts the utilization as well as open disposal of sludge. There are also other metals in the sludge such as iron and aluminium.

Prolonged application of sludge to soil, heavy metals can accumulate in the soil and produce harmful effects on animals and vegetation through the food chain by means of bio-magnifications. Heavy metals present in the sludge is a matter of great concern, for the utilization of sludge or the open disposal the sludge must be treated before final disposal or utilization. Hyde (1976) pointed out that heavy metals are retained in soils by sludge application and can accumulate to the point at which they are toxic to plants. Thus, due to uptake by crops, they may also be toxic to humans and animals. The heavy metal of major concern, because of its possible phytotoxicity and danger to the human food chain, is cadmium (Cd). Cadmium, which is a harmful heavy metal in sludge, has many different sources. Other heavy metals of concern are chromium (Cr), copper (Cu), nickel (Ni) and zinc (Zn), and they are also known to be phytotoxic (Hyde, 1976; Purves, 1990). The observation was confirmed by Rost et al., (2001) who recently reported that heavy metals have long lasting adverse effects on biological functions in soil.

Heavy metals such as zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), lead (Pb), mercury (Hg) and chromium (Cr) are principal elements restricting

the use of sludge for agricultural purposes due to their toxicity. Their potential accumulation in human tissues and bio magnifications through the food-chain create both human health and environmental concerns. The mobility of trace metals, their bioavailability and related eco-toxicity to plants, depend strongly on their specific chemical forms or ways of binding. Concentrations of heavy metals in sewage sludge may vary widely, depending on the sludge origins. Typical metal concentrations are indicated in Table 2.

Table 2: Typical metal content in wastewater sludge (Metcalf & Eddy, 2003)

Metal	Dry sludge (mg/kg)	
	Range	Median
Arsenic	1.1–230	10
Cadmium	1–3410	10
Chromium	10–990,000	500
Cobalt	11.3–2490	30
Copper	84–17,000	800
Iron	1000–154,000	17,000
Lead	13–26,000	500
Manganese	32–9870	260
Mercury	0.6–56	6
Molybdenum	0.1–214	4
Nickel	2–5300	80
Selenium	1.7–17.2	5
Tin	2.6–329	14
Zinc	101–49,000	1700

2.2 Organic compounds

Organic compounds such as pesticides, polychlorinated biphenyls, halogenated aliphatics, ethers and aromatic hydrocarbons are the products of industrial wastewater which could land up in wastewater sludge (Korentajer, 1991; Vorobieva et al., 1996; Kouloumbis et al., 2000). The concentration of these compounds needs to be monitored and limited by implementing source reduction. Most of the organic matter is soluble compounds such as amino-acids, lipids, hydrocarbons or small proteins.

2.3 Pathogens and other microbiological pollutants

Infectious diseases are transmitted primarily through human and animal excreta, particularly faeces. If there are active cases or carriers in the community, then faecal contamination of water sources will result in the causative organisms being present in water. Pathogens in domestic sewage are primarily associated with insoluble solids. Many of these organisms become bound to solids following wastewater treatment and are transferred to wastewater sludge (Bitton, 1994).

As the wastewater treatment processes concentrate these solids into sewage sludge, the sewage sludge has higher quantities of pathogens than incoming wastewater (EPA, 1999). However, the transmission of pathogens can be minimized by reducing the infectivity of sludge through effective treatment processes (Smith, 1996). The actual species and quantity of pathogens present in sewage sludge from a particular municipality depend on the health status of the local community and may vary substantially at different times (EPA, 1999). The four major types of human pathogenic organisms, namely bacteria, viruses, protozoa and helminthes may all be present in sludge. These organisms can cause infection or disease, if humans or even animals are exposed to sufficient levels.

2.4 Nutrients

Sludge also contains a number of different nutrients. It contains about 3% phosphorus and about 4% nitrogen measured by DS content. That is why sludge constitutes such a valuable resource

since these are very important for growing crops. There are macronutrients in the form of nitrogen (N), phosphorus (P), sulphur (S), potassium (K), calcium (Ca) and magnesium (Mg) that growing plants need in larger amounts. The sludge contains low amounts of nitrogen and potassium compared to the needs of different crops. Normally, if sludge is used as a fertilizer, complementing artificial nitrogen and potassium fertilizers have to be used. On the contrary, micronutrients such as chlorine, iron, manganese, zinc, copper, nickel, boron and molybdenum exist in sufficient amounts to meet the need of different crops. There is even a surplus of iron, nickel and sometimes copper.

3. Utilization of Sludge

An alternative for sludge disposal is the utilization of sludge. The various aspects of utilization of sludge were studied but no option was good enough. Utilization of sludge in agriculture is studied and it is concluded that sludge may be utilized with some treatment applied to sludge. The utilization of sludge in agriculture is appropriate due to availability of nutrients in sludge.

Sewage sludge consists of various organic and inorganic matters and contains nitrogen (N) and phosphorus (P) resulting especially from nitrification–denitrification phases in wastewater treatment process, potassium (K) supplements may be needed. Then sewage sludge is very useful for agriculture and green area. There are various sludge forms for agriculture utilization such as dewatered sludge, dried sludge, compost, and incineration ash. However, in respect of fertilizer effectiveness, convenience in handling and sanitary affairs, compost is the most desirable sludge form as a fertilizer.

4. Limitations to Utilization

The stabilized sludge can be used as basis for fertilizers production. Utilization of sludge is desirable since it improves the organic material reconstitution of the soil and has a positive effect on recycling of nutrients. The downside to this usage is that persistent organic pollutants (POPs) tend to accumulate, and fertilizers based on sludge can therefore be a source of pollution.

When sewage sludge is used in agriculture it must be ensured that:

(i) There is no conflict with good agricultural practice;
(ii) The long-term viability of agricultural activities is maintained;
(iii) Public nuisance and water pollution are avoided; and
(iv) Human, animal and plant health are not put at risk.

5. Conclusion

Heavy metals such as zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), lead (Pb), and chromium (Cr) are principal elements restricting the use of sludge for agricultural purposes. Therefore to utilize the sludge the toxic metal concentration must be removed or reduced such that it does not affect the environment and human health. As their potential accumulation in human tissues and bio magnifications through the food-chain create both human health and environmental concerns.

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