Reuse of Sludge

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Abstract: - Sludge production from wastewater treatment process is high, and the disposal of excess sludge will be forbidden in a near future, thus increased attention has been turned to look into potential technology for sludge reduction. The study attempts to review alternative sludge disposal methods, including anaerobic digestion, aerobic digestion and landfills. In these sludge processes, excess sludge production can be reduced up to 100% without significant effect on process efficiency and stability. This study would be useful when one is looking for appropriate environmentally and economically acceptable solutions for reducing or minimizing excess sludge production from wastewater treatment process. Here is the comparison of Sludge disposal methods i.e Anaerobic, Aerobic and Landfills, and carry out the research to find out the cost effective, calorific value and more environment friendly methods like labour cost, capital cost, Operating Cost, Process Time, Space requirement, Odours, Energy Balance, Biogas Production, Sludge production, Energy Cost, Reactor Volume, Application, BOD Reduction and Reliability. Studying the anaerobic, aerobic and landfill methods of sludge disposal to conclude the best suitable method for sludge disposal.

Keywords- BOD, COD, Sludge, Wastewater.

INTRODUCTION

Sludge is the largest by-product from waste water treatment plants and its disposal is one of the most challenging environmental problems in waste water treating processes. Sludge is a by-product of water and wastewater treatment operations. Sludge from biological treatment operations is sometimes referred to as waste water bio-solids. Before sludge can be disposed, it needs to be treated to a certain degree. The type of treatment needed depends on the disposal method proposed. There are principally three final disposal strategies for wastewater sludge and sludge components even though there are many "grey zones" between these are clear-cut alternatives. Sludge and sludge components may be deposited on land (in landfills or special sludge deposits), in the sea (ocean disposal) or to a certain extent in the air (mainly as a consequence of incineration).Disposal of sludge from domestic wastewater treatment plants and Industrial effluent treatment plants (WWTPs and ETPs) is a serious global environmental issue. Some of the commonly adopted methods for disposing the sludge are use of sludge as fertilizer in agriculture, industrial chemicals for example in cement manufacturing, producing energy(biogas), using it as additive in building materials such as bricks, concrete, tiles etc. Reuse of sludge solely depends upon its composition and characteristics. Reusing sludge sludges as a raw material for making burnt clay bricks can be one of the most feasible solution to sludge disposal problem if the final product does not pollute the environment over a longer period.

HOW SLUDE PRODUCED

Wastewater treatment work can be thought of as the kidney of our society, kidney clean blood, wastewater treatment clean water .The basic approach of wastewater treatment is to treat the waste and make it usable. Sewage is screened to remove solid larger than 6mm in 2 dimensions and then the velocity is slowed so that the grit chamber are washed, compacted and disposed. This leaves a suspension of fine solids and dissolve materials in water; the fine solids are settled out by reducing the velocity even more; this leaves primary(secondary) treatment wherenaturally occurring microorganisms feed on the very fine organic matter and dissolve inorganic matter that did not settle out in the primary treatment. Biological treatment is aerobic; it is generally performed using either "biological filter 'comprising beds' of clinker or stone through which air diffused and on which bacteria grow. Or 'activated sludge' (invented in1914 in Manchester and now used around all over the world) where air is bloomed into the liquid objective is that the when the reclaimed water is discharged, is does not strip oxygen from receiving the water. These processes produce excess biomass. Just as breweries produce excess yeast; this is called 'secondary sludge' and is combined with the 'primary sludge'.Very often there are also step to remove nitrate, which was formed during secondary treatment, by biological disinfection, and phosphate either by chemical precipitation or by causing the biomass to take excess phosphate and storing within its cells as polyphosphate these 'tertiary' sludge add to the to the total production of sludge

Perhaps 60% or less of the sludge was present in the sewage directly and 40% or more was grown during wastewater treatment.The term 'wastewater biosolids'(generally biosolids was coined to recognized that (a) much of material was not sedimented from sewage and (b)to differentiate that which is fit for beneficial uses.

CHARACTERISTICS OF SEWAGE SLUDGE

Most wastewater treatment processes produce a sludge which has to be disposed of. Conventional secondary sewage treatment plants typically generate a primary sludge in the primary sedimentation stage of treatment and a secondary, biological, sludge in final sedimentation after the biological process. The characteristics of the secondary sludge vary with the type of biological process and, often, it is mixed with primary sludge before treatment and disposal. Approximately one half of the costs of operating secondary sewage treatment plants in Europe can be associated with sludge treatment and disposal. Land application of raw or treated sewage sludge can reduce significantly the sludge disposal cost component of sewage treatment as well as providing a large part of the nitrogen and phosphorus requirements of many crops. 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 modern 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. The risk to health of chemicals in sewage sludge applied to land has been reviewed by Dean and Suess (1985). Sewage sludge also contains pathogenic bacteria, viruses and protozoa along with other parasitic helminths which can give rise to potential hazards to the health of humans, animals and plants. A WHO (1981) Report on the risk to health of microbes in sewage sludge applied to land identified salmonellae and *Taenia* as giving rise to greatest concern. The numbers of pathogenic and parasitic organisms in sludge can be significantly reduced before application to the land by appropriate sludge treatment and the potential health risk is further reduced by the effects of climate, soil-microorganisms and time after the sludge is applied to the soil. Nevertheless, in the case of certain crops, limitations on planting, grazing and harvesting are necessary. Apart from those components of concern, sewage sludge also contains useful concentrations of nitrogen, phosphorus and organic matter. The availability of the phosphorus content in the year of application is about 50% and is independent of any prior sludge treatment. Nitrogen availability is more dependent on sludge treatment, untreated liquid sludge and dewatered treated sludge releasing nitrogen slowly with the benefits to crops being realised over a relatively long period. Liquid anaerobically-digested sludge has high ammonia-nitrogen content which is readily available to plants and can be of particular benefit to grassland. The organic matter in sludge can improve the water retaining capacity and structure of some soils, especially when applied in the form of dewatered sludge cake.

METHODS OF SLUDGE TREATMENT

- **Blending**

Sludge is generated in primary, secondary and advanced wastewater-treatment process. Primary sludge consists of settleable solids carried in the raw wastewater. Secondary sludge consists of biological solids as well as additional settleable solids. Sludge produced in the advanced wastewater may consist of biological and chemical solid. Sludge is blended to produce a uniform mixture to downstream operations and process.

- **Thickening**

Gravity thickening is the simplest and least expensive process for consolidating waste. Sludge thickeners in waste water treatment are employed most successfully in consolidating primary sludge separately or in combination with trickling filters. Water treatment wastes from both sedimentation and filter backwashing can be compacted effectively by gravity separation. A modest increase in solids content can decrease total sludge volume, entailing size requirements for subsequent treatment units for subsequent treatment units. Sludge treatment methods are usually physical in nature: They include gravity settling, floatation, centrifugation and gravity belts .

- **Stabilization**

Sludge is stabilized to reduce their pathogen content, eliminate offensive odors, and reduce or eliminate the potential for putrefaction. Technologies used for stabilization include lime stabilization, heat treatment, aerobic digestion, anaerobic digestion and composting.

- **Lime Stabilization**

In this process lime is added to untreated sludge to raise the pH to 12 or higher. The high pH environment inhibits the survival of micro-organisms, and thus estimates the risk of sludge putrefaction and odor creation. Hydrated lime and Quick lime (CaO) are most commonly used for lime stabilization. Lime is added prior to dewatering or after dewatering. Lime applied prior to primary clarification precipitates phosphates and hardnesscations along with organic matter. This will help in scale formation and phosphorus can be removed up to 95%. Lime stabilization and heat treatment are very less used.

- **Heat Treatment**

The process involves the treatment of sludge by heating in a pressure vessel to temperature up to 260c at pressure up to 2760kN/mxm for approximately 30 seconds. The exposure of sludge to such conditions results in hydrolysis of proteinaceous compounds, leading to cell distribution and the release of soluble organic compounds and nitrogen. The process also serves for conditioning, as the thermal activity releases bond water and results in the coagulation of solids.
The major disadvantages of heat treatment are its high energy requirement and the production of a high strength return liquid from the dewatering process.

- **Anaerobic Digestion**

The process involves the anaerobic reduction of organic matter in the sludge by biological activity. Anaerobic digestion consists of two stages that occur simultaneously in digesting sludge. The first consist of hydrolysis of the high molecular weight organic compounds and conversion of organic acids by acid forming bacteria. The second stage is gasification of the organic acids to methane and carbon dioxide by the acid splitting methane forming bacteria.

- **Composting**

The objective of sludge composting is to biologically stabilize putrescible organics,destroy pathogenic organisms, and reduce the volume of waste. During composting organic material undergoes biological degradation, resulting in a 20 to 30 percent reduction of volatile solids. In composting, aerobic microorganisms convert much of the organic matter into carbon dioxide leaving a relatively stable odor free substance which has some value as a fertilizer. Eccentric micro-organisms are also destroyed due to the rise in temperature of the compost. Composting includes the following
operation:
1. Mixing dewatered sludge with a bulking agent.
2. Aerating the compost pile by mechanical turning or the addition of air.
3. Recovery of the bulking agent.
4. Further curing and storage.
5. Final disposal.

- **Conditioning**

Conditioning involves the chemical or physical treatment of sludge to enhance its dewatering characteristics. The two most applied conditioning methods are the addition of chemicals and heat treatment. Other conditioning processes include freezing, irradiation and elutriation.

- **Dewatering**

Dewatering is a physical unit operation aimed at reducing the moisture content of sludge. Sludge is not incinerated or land applied it must be dewatered or dried. The selection of appropriate sludge dewatering technique depends upon the characteristics of the sludge to be dewatered, available space and moisture content requirements of the sludge cake for ultimate disposal. Dewatering may be improved by chemical conditioning, such as addition of a polymer. When land is available and sludge quantity is small, natural dewatering systems such as drying beds and drying lagoons are most attractive. Mechanical dewatering methods include vacuum filter, centrifuge, filter press and belt filter press systems. Sometimes sludge is contracted briefly under pressure by a hot surface. The steam generated at the interface between the sludge and the surface forces out some of the water in liquid form. This type ofimpulse drying is suitable when there is sufficient water available to build up steam pressure at the interface.

- **Sludge Drying Beds**

This is a method used for dewatering sludge when space is not a problem then we can use these type of methods as these type of methods are cheaper. Sand beds consist of a layer of sand with an under drain system. The sludge is pumped to the bed. Much of the water drains through the sand and is returned to the plant. The sun and wind dry the material further.

- **Drying Lagoons**

Sludge drying lagoons which are suitable only for the treatment of digested sludge, consist of shallow earthen basins enclosed by earthen dykes. The sludge is first placed in the basin and allowed to dry. The supernatant is decanted from the surface and returned to the plant while the liquid is allowed to evaporate. Mechanical equipment is then used to remove the sludge cake.

REUSE OF SLUDGE IN CONSTRUCTION MATERIAL

- **Waste Sludge In Bricks Production**

Alleman and Berman (1984) developed bricks using mixture of sludge with clay and shale, called biobrick. It was discovered that conventional clay and shale ingredients could be partially supplemented with wastewater sludge has solid content 15-25% to produce biobricks. The biobrick had the look feeland smell of regular bricks (Chin *et al*., 1998). Yague*et al*. (2002) investigated the potential use of dry pulverized sludge in brick production. Dry pulverized sludge was introduced in the production of prefabricated bricks using 2% into the prepared samples and the properties of the specimen were tested, the results shows a significant increase in compressive strength, decrease in porosity and water absorption compare to bricks without sludge.

- **Waste Sludge As Artificial Aggregate**

Tay*et al*. (2002), presented some results from using dried industrial sludge with low organic content and clay which were pulverized separately to fine size before mixing with water to form a paste. The resulting paste was formed aggregate shape and then sintered at high temperature.

The performance of artificial aggregate was evaluated by measuring the compressive strength of concrete samples containing these aggregate compared with granite aggregate. The results showed that 28-day compressive strengths of concrete samples with artificial aggregate ranged between 31-38.5 N/mm^2 while concrete with granite gives 38 N/mm^2, though, the artificial sludge clay aggregates exhibit higher porosity and lower density compared to granite aggregates.

- **Waste Sludge As Cement-Like Material**

Tay*et al*. (2002) investigated the utilization potential of digested and dewatered sludge in the production of cement like material. Specimens were prepared using dried sludge mixed with limestone powder. The resulted mixture was grounded and incinerated. The showed that sludge cement was found to have high water demand and quick setting time compared to ordinary cement. Evaluation of mortar cube strength showed that it was possible to produce masonry binder made of cement sludge that would satisfy the strength requirements of the ASTM standard for masonry cement. Further studies were needed to evaluate long term properties such as durability prior to acceptance as a suitable masonry binder.

- **Waste Sludge Water In Concrete Mixtures**

Chatveera*et al*. (2005) investigated the replacement of tap water with sludge water in concrete production. The study reveals that the sludge water can be used as replacement at percent range of 0-100%. The compressive strength of concrete mixed with sludge water is in the range of 85-94% of concrete with normal water, but sludge water has an adverse effect on drying shrinkage and resistance to acid attack of concrete.

- **Waste Sludge In Ceramic And Glass Production**

Suzuki *et al*. (1997) produce ceramic samples by adding limestone to sewage sludge incinerated ash. The sludge ash is presented as fine dust, so it can be directly mixed with other ceramic paste components. Ceramic samples containing 50% sludge ash showed strength, acid resistance and absorption coefficient within the normal range for ceramic.

RISKS TO PUBLIC HEALTH AND TO THE ENVIRONMENT

Along with the benefits of sludge, there are several problems which must be carefully managed to protect public safety and the integrity of the environment. The most serious of these are the harmful constituents of sludge: heavy metals, toxic organics, and harmful organisms (pathogenic bacteria and viruses, protozoa, and parasites, or worms). Even the nitrogen in sludge can become a problem if not managed wisely, and in excess it can contaminate groundwater or surface waters. In some situations there may also be nuisance factors such as odor, traffic or noise, which could have an impact on land values. The most likely sources of problems in sludge are the presence of heavy metals, particularly cadmium, and the potential for infection by disease-causing organisms.

- **Heavy Metals**

Most research on land application of sludge has focused on heavy metal content and its management. However, the metals of most concern are zinc, copper, nickel, lead, mercury, arsenic and, particularly, cadmium. Metals such as chromium and selenium are problems where industries discharge these into municipal wastewaters. Of the metals commonly found in sludge, cadmium, lead, mercury and arsenic are toxic to humans, and zinc, copper, and nickel are harmful to plants. Lead, mercury and arsenicall three of these may cause acute and chronic poisoning of animals and human beings, including disabilities and death. Effects of chronic poisoning by lead, mercury or arsenic can include brain damage, behavioral problems, poor learning, irritability and depression. Cadmium is another metal which has effects comparable to arsenic, lead and mercury. It is both a chronic and an acute poison, and there have been occurrences of widespread human illness and death from cadmium-contaminated soil, particularly in Japan.

The metal accumulates in the kidney and causes irreversible kidney damage, as well as other symptoms.

- **Pathogenic Organisms**

Infectious organisms found in sludge include bacteria, viruses, protozoa and parasites (worms). Some treatment processes, for example heating sludge, proper composting, or irradiation, kill almost all pathogens. Sludge which is marketed for sale to consumers is generally treated in one of these ways. However, these are relatively expensive treatments, and composting especially must be skillfully done to be effective. Composting does not kill the eggs of intestinal parasites unless heat is added in the process.

Bacteriamost land application utilizes digested sludge, which contains live disease organisms and parasites. Most bacteria die off in the soil after varying periods of time. The bacteria found in sludge which may infect animals are salmonella and bovine tuberculosis; a waiting period of 30 days is considered sufficient to inactivate these bacteria.Many viruses, including hepatitis A and poliovirus, are found in sewage sludge.

Viruses are somewhat more likely, because of their small size, to be carried into groundwater than bacteria are. This problem is still not settled by the research results, although the risk to human health is considered to be low. It is difficult to monitor the presence of viruses in the environment. Only a few years ago it was not realized that viruses can survive in soil. Many viruses still cannot be cultured in the laboratory. There are unknowns, therefore, but after one year in the soil it is not considered likely that virus infections from sludge would be a danger. Three species of protozoa found in wastewater are significant human health risks: the organisms which cause amebic dysentery, giardiasis and a rare dysentery called Giardiasis is a persistent diarrhea which is becoming more common in thePacific Northwest. It is also transmitted in surface waters.hikers and hunters often become infected by drinking from .pure. mountain streams.

- **Nitrates, Salts Etc.**

Nitrate has been found to leach into the groundwater from sludge application sites whenever the amount of nitrogen applied is greater than that needed for fertilizing the plants. This is also true of commercial fertilizers and manure, if present in excess. A small or infrequent leaching of nitrates may be considered acceptable at some sites. Some sludges could contain high concentrations of salts or other materials which would limit their use.

ENVIRONMENTAL PROTECTION

Care should always be taken when applying sewage sludge to land to prevent any form of adverse environmental impact. The sludge must not contain non-degradable materials, such as plastics, which would make land disposal unsightly. Movement of sludge by tanker from sewage treatment plant to agricultural land can create traffic problems and give rise to noise and odour nuisance. Vehicles should be carefully selected for their local suitability and routes chosen so as to minimize inconvenience to the public. Access to fields should be selected after consultation with the highway authority and special care must be taken to prevent vehicles carrying mud onto the highway. Odour control is the most important environmental dimension of sludge application to land. Enclosed tankers should be used for transporting treated sludge, which tends to be less odorous than raw sludge. Discharge points for sludge from tankers or irrigators should be as near to the ground as is practicable and the liquid sludge trajectory should be kept low so as to minimize spray drift and visual impact. Untreated sludge should be injected under the soil surface using special vehicles or tankers fitted with injection equipment. Great care is needed to prevent sludge running off onto roads or adjacent land, depending on topography, soil and weather conditions. On sloping land there is the risk of such runoff reaching watercourses and causing serious water pollution. Sludge application rates must be adjusted accordingly and, under certain circumstances, spreading might have to be discontinued. In addition to the problem of surface runoff, pollution may arise from the percolation of liquid sludge into land drains, particularly when injection techniques are used or liquid sludge is applied to dry fissured soils. In highly sensitive water pollution areas, sludge should be used only in accordance with the requirements of the pollution control authority as well as of good farming practice. Sludge storage on farms can optimize the transport and application operations but every effort must be made to ensure that storage facilities are secure.

CONCLUSION

In developing countries like India, the problems associated with sludge reuse arise from its lack of treatment. The challenge thus is to find such low-cost, low-tech, user friendly methods, which on one hand avoid threatening our substantial sludge dependent livelihoods and on the other hand protect degradation of our valuable land area. The use of constructed wetlands is now being recognized as an efficient technology for wastewater treatment. The investigation shows that sludge can be used as partial replacement for clays (by weight) in burnt clay bricks and other building material. Also sludge used as fertilizer, thus eliminating

the problem of ultimate disposal i.e. landfilling

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