An Overview of Microorganism in Waste Management and Control

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Abstract- Analysis of Microbial action in waste management and control involves the use of diverse microorganisms such as protozoa, Algae, Bacteria, Fungi and Viruses that involved in waste management and then followed by waste categorization and characterization; Domestic waste, Agricultural waste, Electronic waste and scrap metals, Industrial waste and medical waste. The strategies identified for waste management include: Composting, Landfills, Waste water treatment and microorganism as well as primary treatment, secondary treatment and bioremediation. Finally, it has been find out that microorganisms are used to remedy environmental problems or waste management and control as part of recent advancement in biotechnology known as bioremediation.

Index Terms- overview, microorganism, waste, management, control, bioremediation, treatment

I. Introduction

Anthropogenic factors (economic and social activities of man) leads to the generation of large quantities of waste which exit in solid, liquid or gaseous forms. Appropriate management of waste is fundamental activity of social and health importance in human communities. The management of waste involves a variety of activities ranging from collection to transportation, recycling, reuse, salvage and final burial/disposal of un-recycle material. Proper waste management led to a cleaner and safer environment and improved health and welfare of people (Richflood International LTD, 2009).

Empirical studies and practical experiences have shown the ability of geographical information system (GIS) and remote sensing (RS) technologies in this process (De widar 2002); (Eihoz 2006); (Eiselt 2007); (Gemitzi et al., 2007); (Kontos et al., 2003); (Kwarteng and Al-Enezi, 2004); (Tarhan 2005); and (Vuppala et al., 2006). However, non-available open site are managed in accordance with national standards regulating waste disposal (Nie et al., 2004) and (Wang Nie, 2001).

Method of waste disposal dated from ancient times, and sanitary sewers, landfills have been found in the ruins of the pre-historic cities of Crete and the ancient Assyrian cities. Storm-water sewers build by the Romans are still in service today. Although the primary function of these was drainage, the Roman practice of dumping refuse in the streets caused significant quantity of organic matter to be carried along with rain water runoff. Toward the end of the middle ages, below ground privy vaults and, later, cesspools were developed. When these containers become full, sanitation workers removed the deposit at the owners' expense. The wastes were used as fertilizer at nearby farms or were dumped into watercourses or onto vacant land.

A few centuries later, there was renewed construction of storm sewers, mostly in the form of open channels or street gutters. At the first, disposing of any waste in these sewers was forbidden, but by the 19th century it was recognized that community health could be improved by discharging human waste into the storm sewers for rapid removal. Development of municipal water-supply systems and household plumbing brought about flush toilets and the beginning of modern sewer systems. Despite reservation that sanitary sewer systems wasted resources, posed health hazards, and were expensive, many cities built them; by 1910 there were about 25,000 miles of sewer lines in the United States.

At the beginning of 20th century, a few cities and industries began to recognize that the discharge of the sewage directly into the streams caused health problems, and this led to the construction of water treatment facilities. At about the same time, the septic tank was introduced as a means of treating domestic sewage from individual households both in suburban and rural areas. Because of the abundance of diluting water and the presence of sizeable social and economic problems during the first half of the 20th century, few municipalities and industries provided wastewater treatment (Ghose et al., 2006); (Kontos et al., 2003); (Kwarteng and Al-Enezi, 2004); (Tar 2005).

II. Diversity of Microbes Involved in Waste Management

Like any collection of microbes, microbes found in waste water can be arranged in major group's base on certain traits. Microorganisms share some basic features with each other of their kind. The major groups of microorganisms are protozoa, fungi, algae, and bacteria. Viruses, while not consider to be living have some characteristic of living cells; they can also be found in waste water and when in contact with human and ingest can cause disease. Viruses are studied much like microorganisms (Pelczar et al., 1993).

III. Waste Characterization/Categorization

Domestic Waste

Domestic waste form a large volume of waste generated both in rural and urban areas. Dumpsites are majority characterized by these. In general, the data followed trends that have been recorded globally in which the highest per capita waste is generated by the high income earners while the lowest rate is recorded among the lower income groups. Some of the food/vegetable waste can be reduced by composting to produce manure/fertilizer for agriculture or digested to yield biogas which serve as a source of energy, all of which are achieved by the action of microorganisms (Iranzo, 2001); (Garbisu 1999).

Agricultural Waste

This is common in the rural areas where there are vast lands for poultry farming. The wastes generated are used as organic manure in farm land to boost production of crops.

Electronic Waste and Scrap Metals

These are waste majority generated around and found in automobile repairers shops. The metal components are usually sold as scraps. Electronic waste generated in Africa more especially old end of life handsets, television sets, refrigerators, computer parts etc. Alternatively, if there are refurbishing centers more advanced than what is locally practiced and/or recycling centers, these is perceived to reduces the waste stream (Iranzo, 2001); (Garbisu, 1999).

Industrial Waste

These are generated by industries. Studies conducted by World Bank (1995) shows that 30%bof solid wastes are generated from the industrial sectors.

Medical Waste

Medical waste in most hospitals and medical centers are not given any special treatment. Rather, they are mixed with municipal waste. Medical waste is not treated before disposal. Analysis of collected medical waste shows that there are syringes and needles, bandages, nylons, bottles, packaging materials, papers, metals, plastics, human faeces, clothes, food and vegetables as well as leather and rubber. The typical practice is to dig up pits, into which medical waste is dumped. When the pits are filled up, they covered with earth. The unlined pit exposes and increases the risk of ground water contamination (Garbisu, 1999), (Edil, 2003).

IV. Strategies Involved in Waste Management Practices (Waste Handling):

Composting

The composition of waste is analyzed using several physical, chemical and biological measurements. The most common analysis include the management of solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and Ph. The solid wastes include dissolved and suspended solids. Dissolved solid are the materials that will pass through a filter paper, and suspended solid are those that do not. The suspended solid are further divided into settle able and non -settle able solids. All these classes of solids can be divided into volatile or fixed solids, the volatile solids generally being organic materials and fixed solids being inorganic or mineral matter (Kontos et al., 2003).

Composting operation of solid wastes include preparing refuse and degrading organic matter by aerobic microorganisms. Refuse is presorted, to remove materials that might have salvage value or can't be composted, and is ground up to improve the efficiency of the decomposition process. The refuse is place in long piles on the ground or deposited in mechanical systems, where it is degraded biologically to humus with a total nitrogen, phosphorus and potassium content of 1 to 3 percent, depending on the material being composted. After about three weeks, the product is ready for curing, blending with additives, bagging and marketing (Kontos et al., 2003).

The concentration of organic matter is measured by the BOD and COD analysis. The BOD is the amount of oxygen used over a five- day period by microorganisms as they decompose the organic matter in sewage at a temperature of 20C (68 F). Similarly, the COD is the amount of oxygen required to oxidize the organic matter by use of dichromate in an acid solution and to convert it to carbon dioxide and water. The value of COD is always higher than that of BOD, because many organic substances can be oxidized chemically but cannot be oxidize biologically. BOD is used to test the strength of untreated and treated municipal and biodegradable industrial wastewaters. COD is used to test the strength of wastewater that either not biodegradable or contains compound that inhibit the activities of microorganisms. The pH analysis is a measure of the acidity of wastewater sample (see Acids and Bases). The typical values of solids and BOD for domestic wastewater are given in the accompanying table. The organic matter in typical domestic sewage is approximately 50% carbohydrates, 40% protein and 10% fat; the pH can range from 6.8 to 8.0.

	Solids mg/liter			**BOD**	**COD**
Types of solid	**Fixed**	**Volatile**	**Total**	**Mg/liter**	**Mg/liter**
Suspended	70	175	245	110	108
Settle able	45	100	145	50	42
Non-settle able	25	75	100	60	66
Observed	210	210	420	30	42
Total	**280**	**385**	**665**	**140**	**150**

The composition of industrial waste cannot be readily characterized by typical range of values because it make up depends on the type of manufacturing process involved.

Landfills

Sanitary landfills is the cheapest satisfactory means of disposal of solid waste, but only if suitable land is within economic range of the sources of wastes; typically, collection and transportation account for 70% of total cost of solid waste management. In modern landfills, refuse is spread in thin layers, each of which is compacted by a bulldozer before the next is spread. When about 3 m (about 10 ft.) of refuse has been laid down, it is covered by a thin layer of earth, which is also compacted. Pollution of surface and ground water is minimized by lining and contouring the fill, compacting and planting the cover, selecting proper soil, diverting upland drainage, and placing wastes in sites not subject to flooding or high ground water levels. Gases are generated in landfills through anaerobic decomposition of organic solid waste by microorganisms (anaerobic bacteria). If a significant amount of methane is present, it may be explosive; proper venting eliminates this problem (Iranzo, 2001); (Garbisu, 1999); (Edil, 2003).

Waste water (Sewage) Treatment and Microorganisms

Waste water originate mainly from Domestic, industrial, groundwater and meteorological sources and these form of wastewater are commonly refers to as domestic sewage, industrial waste, infiltration, and storm-water drainage, respectively.

Domestic sewage results from peoples' day to day activities, such as bathing, body elimination, food preparation, and recreation, averaging about 227 liters (about 6 gallons) per person daily. The quantity and character of industrial wastewater is highly varied, depending on the type of industry, the management of its water usage, and the degree of treatment the waste water receives before it's discharged. A steel mill, for, example, might discharge anywhere from 5700 to 151,000 liters (about 1500 to 40,000 gallons) per ton of steel manufactured. Less water is needed if recycling is practiced. The processes involved in municipal wastewater treatment plants are usually classified as being part of primary, secondary, or tertiary treatment (Iranzo, 2001); (Garbisu, 1999).

Primary Treatment

The wastewater that enters a treatment plant contains debris that might clog or damage the pumps and machinery. Such materials are removed by screens or vertical bars, and the debris is burned or buried after manual or mechanical removal. The wastewater the pass through a comminutor(grinder), where leaves and other organic materials are reduced in size for efficient treatment and removal later (Iranzo, 2001); (Garbisu, 1999); (Green, 1995).

Sedimentation

With grit removed, the waste water passes into a sedimentation tank, in which organic metals settle out and are drawn off for disposal. The process of sedimentation can remove about 20 to 40 percent of the BOD and 40 to 60 percent of the suspended solids. The rate of sedimentation is increased in some industrial waste-treatment stations by incorporating processes called chemical coagulation and flocculation in the sedimentation tank. Coagulation is the process of adding chemicals such as aluminum sulfate, ferric chloride, or polyelectrolytes to the wastewater; this causes the surface characteristics of the suspended solids to be altered so that they attached to one another and precipitate. Flocculation causes the suspended solids to coalesce. Coagulation and flocculation can remove more than 80% of suspended solids (Green, 1995).

Digestion

Digestion is a microbial process that converts the chemically complex organic sludge to methane, carbon dioxide, and an inoffensive humanlike material. Their actions occur in a closed tank or digester that is anaerobic that is, devoid of oxygen. The conversion takes place through a series of reactions. First the solid matter is made soluble by enzymes, and then the substance is fermented by a group of acid-producing bacteria, reducing it to simple organic acids. The organic acid are then converted to methane and carbon dioxide by bacteria. Thickened sludge is heated and added as continuously as possible to the digester, where it remains for 10 to 30 days and is decomposed. Digestion reduced organic matter by 45 to 60 percent (Green, 1995).

Drying

Digested sludge is placed on sand beds for air drying. Percolation into the stand and evaporation are the chief processes involved in dewatering process. Air drying requires dry, relatively warm weather for greatest efficiency, and some plants have a greenhouse-like structure to shelter the sand beds. Dried sludge in most cases is used as a soil conditioner; sometimes it is used as a fertilizer of its 2% nitrogen and 1% phosphorus content.

Secondary Treatment

Having removed 40 to 60 percent suspended solids and 20 to 40 percent of the BOD in primary treatment by physical means, the secondary treatment biologically reduces the organic material that remains in the liquid stream. Usually the microbial process employed are aerobic that is, microorganisms functioning in the presence of dissolved oxygen, secondary treatment actually involve harnessing and accelerating natures' process of waste disposal. Aerobic bacteria in the presence of oxygen convert organic matter to stable forms such as carbon dioxide, water, nitrate, and phosphate, as well as other organic materials. The production of new organic matter is an indirect result of biological treatment processes, and this matter must be removed before the wastewater is discharge into receiving stream.

Several alternative processes are also available in secondary treatment, including a trickling filter, activated sludge, and lagoons (Heritage, 1996); (Hans, 1995).

Trickling Filter

In this process, a waste stream is distributed intermittently over a bed or column of some type of porous medium. A gelatinous film of microorganisms coast the medium and functions as the removing agent. The organic matter in the waste stream is absorbed by microbial film and converted to carbon dioxide and water. The trickling-filter process, when processed by sedimentation, can remove about 85% of BOD entering the plant (Heritage, 1996); (Hans, 1995).

Activated Sludge

This is an aerobic process in which gelatinous sludge particles are suspended in an aeration tank and supplied with oxygen. The activated-sludge particles, known as floc, are composed of millions of actively growing bacteria bound together by a gelatinous slime. Organic matter is absorbed by the floc and converted it to aerobic products. The reduction of BOD fluctuates between 60 t0 85 percent. An important companion unit in ant plant using activated sludge or a trickling filter is the secondary clarifier, which separates bacteria from the liquid stream before discharge.(Heritage, 1996); (Hans, 1995).

Septic Tank

A sewage treatment process commonly used to treat domestic waste is the septic tank: a concrete, cinder block or metal tank where the solid settle and the floatable materials rise. The partly clarified liquid stream flow from a submerged outlet into subsurface rock-filled trenches through which the waste water can flow and percolate into the soil where it is oxidized aerobically, the floating matter and settle solids can be held from six months to several years, during which they are decomposed aerobically by microorganisms (aerobes).

Bioremediation

Bioremediation refers to the use of microorganisms, especially bacteria, to return the elements in toxic chemicals to their natural cycles in nature. It may provide an inexpensive and effective method of environmental cleanup, which is one of the major challenges facing human society today (Pelczar and Chan, 1993).

Bioremediation has helped in cleaning up oil spills, pesticides, and other toxic materials. For example, accidents involving huge oil tankers regularly results in large spills that pollute coastlines and harm wildlife. Bacteria and other microorganisms can convert the toxic materials in crude oil to harmless products such as co_2. Adding fertilizers that contain nitrogen, phosphorus and oxygen to the polluted areas which promotes the multiplication of bacteria already present in the environment and speeds the cleanup process (Pelczar and Chan, 1993).

Effect of Microorganisms on Petroleum Pollutants

Hydrocarbon degradation by microorganisms is a natural manifestation of the carbon cycle. (Sheilds and Malcolm, 1996). Hydrocarbon pollutant becomes the focus of remediation efforts when they occur in excessively high concentration, prove toxic or are recalcitrant to existing bacterial degradation process. Intrinsic bioremediation therefore, defines the fate of most environmental chemicals whether natural or anthropogenic, through chemical modification such as halogenation; a great deal of efforts has gone into creating classes of hydrocarbons that are more environmentally stable than their unmodified analogs. The recalcitrance of these compounds has led to the attempt to determine why the organisms normally responsible for carbon cycle fail when challenged by certain pollutants.

V. Conclusion

The ultimate fate of all living matter is death and subsequent decay of dead organisms known as degradation, by the action of microbes on the dead organism. This is a natural phenomenon in nature, which has been effectively manipulated by biotechnologist in recent scientific advancements, and harnessed to accelerate the degradation of pollutants; backed up by optional conditions for metabolic activities. This whole concept is what is known as waste management. It simply refers to the revitalization of polluted environments to their natural conditions or at least close to it. The first step of waste management is waste reduction. Therefore, it is essential to minimize the quality of waste generated.

References

[1] Edil, T.B. (2003). A review of aqueous –phase VOC transport in modern landfill liners, *Waste Management***23**, pp. 561571

[2] Eihoz, M. (2006). Use of GIS techniques as decision support tool for sanitary landfill sitting, *Solid Waste Technology and Management* (2006), pp. 5210530.

[3] Eiselt, H.A. (2007). Locating landfill optimization vs reality, *European Journal of Operative Research* **179** pp. 10401049

[4] Garbisu, Carlos and Alkorta, I. (1999).*Technology and Journal of Chemical Biotechnology*, vol. 106.

[5] Inanc B., Idris, A., Terazono A., and Sakai S. (2004).Development of a database of landfills and dump sites in Asian countries, Journal of Material Cycles and Waste Management **6** pp. 97103.

[6] Iranzo, M. Sainz-Pardo, I. Boluda, R. (2000).*The Use of Microorganism in Environmental Remediation*, vol. 51, issue 2.

[7] Komiya, T., Ishizaki, N.H. and Shamaoka T. (2006). Applicabilty of NDVI on estimate of stabilization of large- scale landfill, *System Environmental Research***34** pp. 423431.

[8] Kontos D., P. Komilis and C.R. Halvadakis. (2003).Siting MSW landfills on Lesvos Island with a GIS-based methodology, *Waste Management and Research***21** pp. 262277.

[9] Macleod C., R. Duarte-Davidson, B. Fisher, B. Ng, D. Willey, J.P. Shi. I.M artin, G. Drew and S. Pollard. (2006). Modeling human exposures to air pollution control (APC) residues released from landfills in England and Wales, *Environment International***32** pp. 500509.

[10] Mahini and Gholamalifard, (2006), A.S. Mahini and M. Gholamalifard, Sitting MSW lansfills with a weighted linear combination methodology in a GIS environment, *International Journal of Environment and Technology***3** (2006), pp. 435445.

[11] Shields, M.S., Synder, R., Reagin (1993), Bioremediation of TCE.

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