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Waste Management: A Review

Divya Tamma[1]* and Nitin Panwar[2]

[1]Department of Biotechnology, Sheffield Hallam University, UK
[2] Department of Biotechnology, Graphic Era University, India

Review Article

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***For Correspondence**
Divya Tamma, Department of Biotechnology, Sheffield Hallam University, UK, Tel: +91-9989239898.

E-mail: divya.tamma88@gmail.com

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ABSTRACT

Waste management is a new edge through which we can manage the miscellaneous type of waste generated throughout many industrialized and regular procedures. This article gives an ephemeral review on how to manage waste from the point of origin to its decomposition and also laid emphases on why there is a need for management of Organic and Inorganic waste and their adverse effects on environment.

INTRODUCTION

According to, Department for Economic and Social Information and Policy Analysis (USA), waste management is all the activities and actions required to manage waste from its inception to its final disposal [1]. The term waste management includes treatment of all kinds of waste, from its point of generation, extraction, processing of raw materials to their final product consumption. Waste is generally produced during human activities, municipal, agricultural or social activities, to avoid the environmental disturbances caused by their disposal in to nature; waste management is highly recommended.

During old days waste produced is of less percentage, because of the less population and minor use of natural resources. Waste was mostly from ashes produced from burnt things or slight social activities. The ashes and human biodegradable waste thus produced was released back in to land or atmosphere leaving minimum environmental impression. The household utensils are mostly made of wood or metal, which were passed on to future generations or reused [2-4]. The early 20th century set the industrial revolution followed by population growth around the world expanding the urban areas. This ultimately led to buildup of waste resulting rapid deterioration of sanitation levels and quality of life in metropolitan cities.

Benefits

With environment at risk one should consider that waste is not something that is disposed without concern of its consequences and future use. It can be served as valuable resource, if it is treated right and processed with good practice. Globally waste management has wide range of benefits. From economic benefits to social, it has huge impact [5]. Those benefits include:

Economic benefits: Economy is considered important among all the factors of a country. Waste management can help in improving economy very efficiently, if waste is treated and recycled. With the natural resources at risk and in search of alternate energy resources, waste can be used to create markets for recycling and an energy source. Efficient practicing of this treated waste in production and consumption of valuable products can lead to recovered materials, new jobs, business opportunities and finally impacting social economic status.

Social: Health deterioration is the major adverse effect caused by environmental degradation. By continues practice of waste management, health risks are reduced, resulting better societies. Improved social advantages give rise to employment opportunities and uplifting of community from poverty [6].

Environmental: Waste disposed in to the environment is not only a harm to human but also to animal and plant kingdom. By reducing their adverse effects can provide better quality of air, water and reduction of greenhouse gas emissions. Reusing and recycling of waste can result in minimizing the exploration of natural resources and improvement of environment.

Inter-generational equity: Leaving a better planet for future generations is a human responsibility. With right waste management practices, future generations can be provided with better economy, more inclusive society and a cleaner environment.

INDUSTRIAL WASTE

Industrial waste is defined as a liquid, solid and gaseous wastes originating from the manufacture of specific products [1]. It is the mixture of several varieties of impurities and this reason alone makes its treatment, a special task. Considering its threat to environment, manufacturing companies started prioritizing the closed circuits and product recovery methods in various production processes. By introducing these methods to treat the waste, can contribute to the protection of eco-system and reducing the cost of production too. WABAG is the long-term experience in the industrial wastewater treatment sector. Mechanical, biological and chemical physical process is the steps followed during waste treatment. During biological treatment of waste water, it is exposed to anaerobic treatment, as it is considered as conventional, space saving and high performance process [7]. Depending on the characteristics of waste, several other processes are also implemented. Rapid industrialization led to growth of industrial sectors like sugar, pulp and paper, fruit and food processing, sago starch, distilleries, dairies, tanneries, slaughterhouses, poultries and many more [8]. These industries generate huge quantity of solid and liquid wastes. Regardless of the policies introduced by pollution control, waste produced is generally dumped on land or discharged in to water bodies, resulting in environmental pollution and health hazard.

Organic Chemicals

Pesticides, pharmaceuticals, paints, dyes, petroleum, detergents, plastics, paper pollution [9].

Tanning Industry

Economic status of any country is hugely influenced by its industrial production and marketing. Leather processing and tanning industry contributes hugely to economic activity all around the world. But processing of leather leaves an uncontrolled tannery effluent. When these effluents are released in to natural water bodies without prior treatment, can lead to environmental degradation and health hazard to human beings [10]. The tannery effluent produced from traditional or conventional leather processing contains a high concentration of organics (COD/BOD), Suspended Solids (S.S) and inorganics like NH4-N, SO42- /S2-, Cr(III) and Chlorides [11-13]. These organic and inorganic products from tannery effluent can cause health risks to aquatic ecosystem, human and environmental degradation [8]. Toxic chemicals in tanning effluents cause depletion of oxygen in water and affect the fishes, other aquatic flora and fauna [14].

Dyes: Water released from textile dye manufacturing and dyeing mills consist of large amounts of colored effluents [15]. Color is the first pollutant to be considered in wastewater [16] as it blocks the sunlight passing in to water. The estimation of total dye consumption worldwide is more than 107 kg/year [17]. Congo red (CR) is anionic dye that has benzene [18] and malachite green (MG) is a cationic dye [19]. In aqueous solution, anionic dyes carry a net negative charge due to the presence of sulphonate ($SO3-$) groups, while cationic dyes carry a net positive charge due to the presence of protonated amine or sulfur containing groups [20]. Dyes in industrial effluent can cause allergic dermatitis, skin irritation, dysfunction of kidney, liver, brain, reproductive and effects to central nervous system [21-22]. Due to presence of high color compounds, dyes are considered to be toxic and even carcinogenic [23-24]. Even in minute concentrations, these toxins widely affect the aquatic ecosystem and make water unacceptable for various household or agricultural purposes [25].

Treatment

- Various techniques like adsorption, nano-filtrtion, electro kinetic coagulation, coagulation and precipitation, advanced chemical oxidation, electrochemical oxidation, ozonation, liquid-liquid extraction and few other biological process can be employed for the removal of textile dyes from wastewaters [26]. Adsorption is the most promising and extensively used method for removal of both inorganic and organic pollutants from contaminated water [27]. Activated carbon have unique molecular structure, high porosity and an extensive surface area, this reason alone makes it an effective adsorption technique for dye removal [28].
- An organic pollutant from industrial waste is the reason for waste water being considered pollutant, adsorption by activated carbon is considered to be the best management for treating organic waste. Rhodamine B is a water soluble and basic red cationic xanthene class dye that is commonly found as tracer fluorescent. Activated carbon that is developed from coconut shell can be applied for removal of Rhodamine-B from wastewater successfully.
- The methylene blue number, iodine number and BET surface area of the prepared carbon were found to be 80 mg g-1, 600 mg g-1, and 1200 m2 g-1 respectively [29]. AE (2015) investigated that sodium dodecyle sulfate coated tea waste (SCTW) has excellent adsorption capacity for the removal of methylene blue from aqueous solutions. It can be concluded as a promising advanced adsorbent in environmental pollution clean-up.

Fossil Fuels

Power stations, coal-fired plants, lead, mercury, cadmium and chromium, as well as arsenic, selenium and nitrogen compounds. Fossil fuels are formed by natural processes such as anaerobic decomposition [30] of buried dead organisms, containing energy originating in ancient photosynthesis [31]. Fossil fuels contain high percentages of carbon, petroleum, coal, natural gas, kerosene and propane [32]. Fossil fuels contain volatile materials with low carbon: hydrogen ratios like methane, liquids like petroleum and nonvolatile materials like pure carbon and anthracite coal. Methane can be found in hydrocarbon fields either alone, associated with oil, or in the form of methane clathrates [33].

Crude oil: Oil wastes that are produced from crude oil companies, when dumped or burned without treating leave a huge risk to both ecosystems and human health and causes serious environmental consequences [34].The chemical composition of oil sludge is complex and depends on the source. It is mainly composed of alkanes, aromatics, asphaltenes and resin [35-38]. The common contamination caused by crude oil companies is spillage of its waste oil in to aquatic environment due to leakage in to water body, during the process of oil exploration and transportation [39]. This contamination cause disturbances to aquatic environment and is a big threat for the evolution of macrophyte [40]. The toxic chemicals present in the crude oil, depending on its water soluble fraction (WSF), can also be lethal in acute or chronic levels [41-43].

These toxins in crude oil carry specificity of finding their way in to the body system of aquatic animals (Fishes) through the gills, digestive tract and general body surface causing significant damage to the internal organs and tissues [44]. Research says that there is a relationship between contaminants exposure, various biological responses and changes to target organs of fish [45]. Some authors argue that histological alterations are sensitive tools that can be used to detect the effect of different toxins and different compounds on different organs, altogether as a good environmental stressor indicator for bioassay [46-47]. Fish exposed to pollutants [48] such as crude oil effluents cause histopathological changes in different tissues and organs such as gills, liver, kidney, spleen [49]. Depending on the stressor and the intensity of toxic agents, histological changes differ [50-53].

Automotive sector: Rapid industrialization and automobiles led to excessive use of fossil fuels and to serious environmental problems like climate change, deterioration of the ozone layer and acid rain. With natural resources at risk due to their extreme exploitation, new energy search has become a need. Thus biofuels is a great alternative [54]. Biodiesel that is produced from microalgae is considered as promising alternative because of its high growth rate, high capacity for lipid accumulation, CO2 absorption capacity and ease of cultivation both outdoor tanks (raceway) and in closed reactors (photobioreactor) [55-57].

Alternative

- In search of alternative energies, industrialized countries started developing their primary energy fuel from renewable resources such as solar energy, wind energy, geothermal energy, biomass energy, hydropower, ocean energy and secondary energy source such as hydrogen energy.
- Proton Exchange Membrane Fuel Cell (PEMFC) is one of the alternative energy. In PEMFC, the chemical energy is converted directly into electricity and then to heat. It is estimated that PEMFC become an efficient and clean energy by 2020 [58]. One can conclude that automotive industry is developing, changing and playing a vital role in determining the fuel choice [59].
- Biogas is another alternative energy source. Biomass can efficiently produce methane and biogas when treated with fungal co-cultures of *Trichoderma viride*, *Aspergillus niger* and *Fusarium oxysporum*. This biological pretreatment is effective and cost reducing [60].
- Simarouba (*Simarouba glauca*) is commonly known as paradise tree. As per ASTM specification biodiesel, this paradise tree possesses important fuel properties [61]. Research says that automobile engine works smoothly on simarouba methyl ester when compared to diesel operation. Thus simarouba biodiesel can be successfully substituted as alternative fuel for CI engine.
- To reduce the effects of fossil fuel utilization and of economic interest, there is continues interest in search of renewable energy. Animal fats and vegetable oils can produce ethanol that can be used for primary renewable transportation [62]. The fatty acid methyl esters from animal fats and vegetable oils, referred to as biodiesel, can provide significant reductions in particulate matter, CO and HC emissions [63]. Alternate fuels which are extracted from vegetable oils will positively reduce the usage of fossil fuels. Oil extracted from orange peel and

cotton seed can be used as alternate energy when it is blended with petrol and used in petrol Engines. Advantage is no modification of engine is needed for this application [64].

FOOD AND AGRICULTURE

Though waste from food and agriculture is considered biodegradable and non-toxic, it has high concentrations of biochemical oxygen demand (BOD) [65-67] and suspended solids (SS).

The differences in BOD and pH in effluents from vegetable, fruit, and meat products, seasonal nature of food processing and post-harvesting, makes food and agriculture waste complex to treat. According the Natural Resources Defense Council [68] more than 40% of the food in the United States is wasted during crop production, transportation and final consumption, which accounts for $165 billion, each year go to trash. Produced food waste ends up in landfills and release methane in to the atmosphere [69] which is another form of air pollution.

Treatment

- Food wastes are rich in organic matter and during degradation, produce methane, a greenhouse gas. This waste can be utilized to produce biogas, under conditions like feedstock characteristics reactor design and anaerobic digestion process. To achieve food waste treatment and its conversion into biogas two steps are carried out, one in single phase and other in high-rate two-phase anaerobic digestion [70-73].
- The organic matter from agricultural crops and wastes, animal wastes, forest and wood residues, plants and municipal waste is called biomass and is stored as chemical energy. This energy can be released as biogas such as methane (CH_4), hydrogen (H_2) and carbon dioxide (CO_2) through the anaerobic digestion process [74-77].
- Sugarcane waste-Press mud can be utilized for biogas production. When industrial waste is subjected to anaerobic digestion in a laboratory large scale floating drum bio digester with two different conditions, biogas yield is obtained from dry pressmud and methane concentration (CH_4) can be reached to 67% compared to wet pressmud [78]. Hence industrial waste (pressmud) is potential source for energy production.

MINING

Recovery of ores like metals, coal, oil shale, gemstones, limestone, dimension stone, rock salt, potash, gravel, and clay.

Iron

A powerful reduction reaction in blast furnaces is applied during production of iron from its ores and water is used for cooling, during this process the effluent produced is inevitably contaminated with ammonia and cyanide [79]. Production of coke from coal in coking plants and by-products separation include water cooling process. Benzene, naphthalene, anthracene, cyanide, ammonia, phenols, cresols and wide range of more complex organic compounds known collectively as polycyclic aromatic hydrocarbons (PAH) from these industry effluents are considered carcinogenic.

Heavy Metals

Population growth directly affected increased need for natural resources and its exploitation has become an important economic activity worldwide. But adverse effects are hugely due to its poor exploitation processes and wrong disposal of mine tailings [80-81]. Several researchers say that heavy metals are bio concentrated or bio accumulated in one or several compartments across food webs [82-83]. This contamination of natural ecosystem with trace of toxic elements directly affects the natural functioning of aquatic organisms and indirectly become reason for decrease in biodiversity and extinction of sensitive taxa [84]. Metal bioaccumulation is considered important in regard to human health, especially when humans consume the accumulators. This phenomenon is considered important in assessing environmental quality and chemical survey of water and sediment [85]. Heavy metals enter the aquatic environment mainly by anthropogenic sources. Fish is at the top of the aquatic food chain, and during its life can accumulate large amounts of toxic elements [86-89]. Another form of heavy metal contamination is in residential areas, where most of Pb contamination is attributed to the deterioration of lead-based paint for housing [90].

Toxins

Chronic exposure to benzene at minimum concentrations can cause leukemia, mercury and cyclodienes, kidney damage and sometimes these effects are irreversible. PCBs and cyclodienes leave toxic effects on liver. Organophosphates and carbamates on chronic level induce a chain of responses leading to neuromuscular blockage. Chlorinated solvents induce liver changes, kidney changes and depression of the central nervous system [91-94]. Toxins carrying heavy metals can cause headache, nausea, fatigue, eye irritation and skin rash.

Treatment

- A new technique called Phytoremediation is developed recently, it is considered as an effective technology for treating heavy metals. It uses plants to degrade, assimilate, metabolize, or detoxify metals, hydrocarbons, pesticides and chlorinated solvents. To treat a variety of hazardous chemicals, phytoremediation is a best approach and it is cost-effective and resource-conservative technique [95].
- Scolecite natural zeolite is capable of removing metal ions Ni2+, Pb2+, Zn2+, Cd2+, Fe3+, Cr3+ from industrial waste water samples. The percentage of removal of heavy metal ions by scolecite is 95 % and 99.9% of Ni2+, Pb2+, Zn2+, Cd2+, Fe3+ and Cr3+ can be removed. Thus natural zeolite can be used effectively for the removal of these metal ions from industrial wastewater [96]. This naturally occurring material provides a substitute for the use of other materials as adsorbent due to its availability and low cost. Thus treated industrial waste water can be reused for washing, irrigation etc.

PULP AND PAPER INDUSTRY

Furans, phenols, insecticides

Wool

During Wool processing, flees are treated with water and thus produced water get contaminated with animal fats and chemicals from insecticides.

Paper

The industry of pulp and paper produces effluent that is high in suspended solids and BOD [97]. Plants that bleach wood pulp for paper making may generate chloroform, dioxins, furans, phenols and chemical oxygen demand (COD). Pulp and paper mills utilize huge amount of lingo-cellulosic components of plants and chemicals during their manufacturing and considered as polluting industries because of huge amount of waste material that is released into the environment [98].

Pulp

It is produced by 40-50% of plant materials, which are heavily with organic material. Thus produced effluent composes of compounds like chlorinated lingnosulphonic acid, chlorinated resin acid, chlorinated phenol and chlorinated hydrocarbon and many more organic chemicals. As a result of different processes applied in wood and pulp bleaching, this industry discharges large volumes of brown colored effluents that are diverse in nature [99-100].

Due to their high chemical diversity in nature, these pollutants cause clastogenic, carcinogenic and mutagenic effects on fish and other aquatic communities in recipient water bodies [101].

Treatment

- The best possible way of treating effluents from paper mill plants is primary clarification succeeded by secondary treatment, generally of a biological nature. There are numerous biological treatment systems available and the most common is the activated sludge process [102-103].
- Activated sludge system technology is a process where agitation of the effluent is achieved, in the presence of aerobic bacteria, protozoa, metazoa and atmospheric oxygen for a sufficient period to metabolize and to flocculate a large part of the organic material.
- Protozoa play a secondary but important role in wastewater system purification [104-105].The protozoa in the activated sludge treatment process are of four main classes: amoebae, flagellates and ciliates and metazoa that are separated into rotifers, nematodes and Oligotrichia such as Aelosoma [106].Industrial effluents composing of specific characteristics are treated with activated sludge process and depending on specifications, kind of protozoa are used [107-108].
- Phenol is an organic compound that is widely used in petrochemical, oil refining, plastic, leather pharmaceutical and pesticide industries. Papita Das et.al, (2015), suggested that soil adsorbent can be implemented as an efficient liner material for the removal of phenol and phenolic compounds from wastewater [109].

CONCLUSION

Rapid industrialization, population growth and many other social factors contributed to the increase in production of waste and environmental disturbances caused by them. Consequently these changes in environment are affecting whole food chain. This review article laid emphasis on treatment of waste produced from industries or household, before its disposal in to nature, either water bodies or land. Thus treated waste is economically and socially beneficial to the humans and their environment. The organic wastes like dyes can be reused after treatment and they are not hazardous to the habitat if released after adsorption of harmful chemicals. Instead of using fossil fuels, the renewable energy resources can be brought into use. The agricultural waste can be minimized by using them as biodegradable sources of energy production. Phytoremediation is a new technology that minimizes the waste rendered from mining. Considering the responsibility to leave a better planet for next generations, this exploitation of natural resources should be minimized to a great extent. By reusing and recycling the waste, one can reduce the adverse effects on environment.

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