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A Review Article on the Role of Microorganisms in Domestic and Industrial Sewage Treatment

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Abstract

Sewage has always been the crippling problem to our planet, since the amount of waste increase as the population increases. This review focuses on the fundamental concepts on sewage and its treatment methods. Despite advances in water and sewage treatments, the biological methods are of major importance in sewage treatments to be cost effective, efficient and environmentally friend. The role of the different microbial groups presents in the waste water treatment systems with particular importance of bacteria and protozoa in the removal process of nitrogen and phosphorus indicate that the biological treatment system is very effective in the wastewater treatment systems. For this, certain microorganisms such as bacteria are showed to be highly versatile in treatment of sewage than the others Furthermore, the formulated many of microorganisms are efficient for sewage treatment and thereby it reduced the environmental impact.

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Biological methods, Microorganisms, Sewage, Sewage treatment.

Introduction

Sewage is any waste that carried by water from different sources. The sewage has always been the crippling problem to our planet, since the amount of waste increase as the population increases (The Energy and Resources Institute (TERI), 2014). Therefore, highly organized and efficient system of sewage or waste treatment is needed to overcome this problem. The sewage is generally classified as domestic and industrial sewage depending up on its source from where the waste is produced. The sewage that produced from daily house hold activity is called the domestic sewage (Ali and Eyasu, 2017). The industrial sewage is produced from daily activities of industries manufacturing process (TERI, 2014). The industrial sewage is mostly characterized by carrying toxic substance such as Cu, Co and other toxic byproducts (Ebtesam *et al.*, 2013). The domestic sewage also may carry toxic substance but its content is less than that of the industrial sewage (TERI, 2014). It is characterized by possessing pathogenic and non-pathogenic microorganisms (Bawiec *et al.*, 2016; Muhammad *et al.*, 2017).

Currently available methods of sewage treatment are the chemical and biological sewage treatment. However, the biological methods are the leading because of their efficiencies and inexpensiveness (Akpor *et al.*, 2014). The biological methods are mostly effected via the system of Activated sludge, Trickling filter, Member bioreactor, Stabilization pond (TERI, 2014). Bacteria, fungi, protozoa, virus, algae and worms play great role in

biological system treatment processes. However, bacteria and fungi are remained to be the predominant in waste treatment plant. The aim of this review is to show the contemporary advanced science about the role of microorganisms in the sewage treatment by reviewing recently published relevant articles.

Sewage

Sewage can be defined as a waste which is carried by water in a solution or suspension. Only one percent is solid particles, the 99 % of the sewage is water in its content (TERI, 2014; Ram *et al.,* 2011). The sewage is classified as domestic and industrial waste depending upon the sources of the waste (TERI, 2014).

Domestic sewage

Domestic sewage is a waste that generated from daily household activity such as from food preparations, sweeping, washing clothe, garden waste and used items like clothing, furnishing and discarded equipments (Ali and Eyasu, 2017). The domestic waste is characterized by rate flow, physical conditions, chemical composition and organisms it carries (TERI, 2014). It may carry biodegradable as well as non-degradable waste and pathogenic microorganisms (Bawiec *et al.,* 2016; TERI, 2014). Bawiec *et al.,* (2016) found that the domestic waste contains both human threatening and potential bacterial pathogens. Species that threaten human or aquatic organisms are *Klebsiella pneumonia, Bacillus macenensis*, *Camamonas nitrativorens* and *Aeromonas hydrophila*. *Potentially* pathogenic species are *Escherichia coli Pseudomonas luteola* and *Providencia rettgeri*. In the study done in Saudi Arabia, different viral families were identified in waste water. RAN virus which are belong to families Closteroviridae, Endornaviridae, Sobernoviridae, Leviviridae, Secoviridae, Dicistroviridae, Picornaviridae, Orthmyxoviridae, Picorbirnaviridae, Varicosaviridae, Potyviridae, Betaflexviridae, and Astroviridae were presenedt in the influent (Muhammad *et al.,* 2017).

Industrial sewage

Industrial sewage is a waste that carried by water and produced or discarded from cleaning fluids, pesticides, or by product of manufacturing process (TERI, 2014). It is differ from domestic waste both in quality and characteristics (Ram *et al.,* 2011). The industrial waste can be classified as hazardous and nonhazardous waste depending up on its content. The hazardous waste is toxic even contains heavy metals and radioactive element. However, the non-hazardous waste is non-toxic which resembles domestic waste (TERI, 2014).

Sewage treatment

Sewage treatment is the process by which the contaminant and pollutant matters are removed from the waste water via chemical and biological methods (Akpor *et al.,* 2014; Ram *et al.,* 2011). Due to some disadvantages and expensiveness of chemical methods, biological methods are currently employed (Akpor *et al.,* 2014). In sewage treatment system, waste management is needed in which citizens, industries; local government and pollution control board have joint responsibility. The waste management comprises activities such as segregation, collections, transportations, reprocessing, recycling, and disposal of the waste (TERI, 2014). The currently employed sewage treatment has 4 general steps: preliminary treatment, physical-chemical treatment (primary treatment), biological treatment (secondary treatment) and advanced treatment (UNIDO, 2011)

Preliminary treatment

This step is mostly applied for tannery cluster that often found in developing countries in which individual tanneries have their own pretreatment unites. The role of this stage is to remove large particles, sand, grit, grease before the effluent is discharged into the collection network (UNIDO, 2011).

The physical-chemical treatment (1^{o})

In this step, settable organic and inorganic solids are removed via sedimentation process. The removal of materials that will float (scum) is achieved by skimming (TERI, 2014; UNIDO, 2011). More or less 90-95% of settable solid removal is recorded by this process. Approximate amount of suspended solid that removed is about 50-65% (TERI, 2014). About 25-50% of the incoming BOD and 65% of the oil are removed during primary treatment (UNIDO, 2011).

Biological treatment (2^{o})

The role of this step is to remove biodegradable dissolved and colloidal organic matter using microorganism of which mostly are bacteria. The aerobic microorganism metabolizes the contaminates and produce inorganic output ($C0_{2,}$ H_20) (TERI, 2014;

UNIDO, 2011). The BOD is highly reduced in this step (TERI, 2014).

Advanced treatment (3^0)

The advanced treatment is mostly employed to meet the specified discharge limit which is steed by pollution control board. The process employed here is includes coagulation, sedimentation and oxidation (TERI, 2014). This steps is also performed so as to reduce the residual COD and when specific waste water component are not fully removed in pervious process (UNIDO, 2011).

The biological system of sewage treatment

The application of conventional technologies other than biological system to treat waste water is found to be expensive and inefficient (Richa and Amita, 2016). Moreover, this technologies produce secondary contaminates which again spoils the environment (Maulin, 2017). The biological system also called biodegradation can be defined as the reduction of waste by using organic methods or microorganisms. This process is generally divided into two categories. The first categories are direct reduction of waste via using biological system which includes aerobic and anaerobic conversion of waste. The second is the reduction of waste by biochemical methods including chemical processing, and or the selected extraction from specific species of protozoa or fungi (TERI, 2014). During the aerobic degradation process, organic materials is oxidized to produce hums and inorganic end product (Varsha, 2016; TERI, 2014). Microbes depends on contaminate for their source of energy by which they break the chemical bond of the contaminates and transfer electrons from the contaminate to electron accepters such as oxygen. They invest energy with some electrons and carbon from the contaminate to produce more cell (Varsha, 2016). In the anaerobic digestion, methane is produced which is highly marketable product. The process starts first by breaking down the complex materials in the waste to organic acid and carbon dioxide. The methanogenic bacteria then produce methane and carbon dioxide by digesting the organic acid (TERI, 2014). Generally, the biological sewage treatment have numerous application in decontamination of contaminated area such as water, soil, sludge and flows (Maulin, 2017). The biological system is mostly effected by aerobic system of sewage treatment such as Activated sludge, Trickling filter, Member bioreactor, Stabilization pond and Constructed wetland (Akpor *et al.*, 2014; TERI, 2014). These process are employed in the second sewage treatment and the variation among the process is primarily depends on the manner of oxygen supplying methods to microorganism and with the rate at which organism metabolize organic matter (UNIDO, 2011).

Activated sludge

In 1914, industrial microbiological became familiarize with the application of microorganism in waste water treatment which enable them to develop a highly versatile biological treatment known as activated sludge process (Hiral and Maulin, 2017). Activated Sludge is a process by which microbes degrade organic matter in the presence of oxygen to produce in organic matter (Akpor *et al.*, 2014; TERI, 2014). The mixed liquid from the primary treatment is allowed to settle for separation of suspended solid from the waste water. The gravitational force separates the solid from the waste water (Akpor *et al.*, 2014). The liquid fraction of the waste allowed to aerated in the aeration tank in order to feed O_2 to the microorganisms. Some of the concentrated biological solid are allowed to recycled back to the aeration tank so as to maintain a concentrated population of microorganisms to treat the sewage. The floating materials which are not digested are incinerated. Finally, this system produces or discharge water is reduced in BOD (about 90-95%) to the environment (TERI, 2014).

Membrane bioreactor

Membrane bioreactor is one of a biological system that use inorganic polymers as membrane to replace the gravitation setting of the conventional activated sludge system (Akpor *et al.*, 2014). This process is efficient in removing virus particles which are mostly belong to RNA virus such as family Closteroviridae, Endornaviridae, Sobernoviridae, Leviviridae, Secoviridae, Dicistroviridae, Picornaviridae, Orthmyxoviridae, Picorbirnaviridae, Varicosaviridae, Potyviridae, Betaflexviridae, and Astroviridae (Muhammad *et al.*, 2017). These system allow complete physical ration of bacteria flocs and all suspended solid within the bioreactor (Akpor *et al.*, 2014).

Trickling filter system

Trickling filter system is made up of a filter bed in which the microorganisms form a biofilm. The beds contain a highly permeable media that has a layer on which the microorganisms found to form a slim layer. The bed of the system can be rocks, molded plastic, gravel and

ceramics etc. Aerobic microorganism that grows on the media trap (trickl) the organic waste and metabolize it to produce carbon dioxide and water. This system is less efficient then the activated sludge by removing 80%-85% of the BOD. However, easier to operate (Akpor *et al.,* 2014; Davood *et al.,* 2013).

Stabilization pond system

Stabilization pond system is a pond that constructed and allowed to be opened. This system involves the natural method of disinfection mechanisms (Akpor *et al.,* 2014). This system is cost effective since it is simple to construct, operate and maintain. Furthermore, it does not use expensive electromechanical equipment and is efficient in removing pathogenic microorganism in producing high effluent quality with low BOD (Akpor *et al.,* 2014; TERI, 2014).

The role of microorganism in domestic and industrial sewage treatment

Microorganisms play a great role in treatment of waste water (both domestic and industrial), bioremediations of soil, detoxification of chemical waste and etc. These microorganisms are mostly from the group of bacteria, fungi and protozoa. Nonetheless, virus and algae are also having a role in the treatment plant (Maulin, 2017)).

Role of bacteria

In both domestic and industrial waste water, bacteria play indispensable role in converting the waste organic matter, heavy metals and other substances to less complex compound (Akpor *et al.,* 2014; Maulin, 2017). In the waste treatment plant especially in activated sludge, bacteria is responsible for formation of folck particles on which cluster of bacteria break down the waste matter or absorbs it. Despite of both and autotrophic presence in the waste water treatment plant, heterotrophic bacteria is predominately existing since they depend on the waste matter (Akpor *et al.,* 2014).

The role of bacteria in both domestic and industrial waste water treatment can be classified as Heavy metal detoxification, BOD and COD reduction, dehalogination, dinking and removal of oil contaminates.

BOD and COD reduction

The activated sludge of both domestic and industrial sewage treatment composed of different species of bacteria such as *Bacillus, Achromobacter, Pseudomonas stutzeri, Pseudomonas putitda, Pseduomonas mendocina, Zooglea remigera, Arthrobacter, Alcaligens faecalis, Flavobacterium, Micrococcus, and Rhodococcus specie.* The reduction of COD and BOD as well as removal of ammoniacal nitrogen is documented for *Pseduomonas* (Maulin, 2017).

Dinking

Pseudomonas putida, Bacillus and Citrobacter are known for their discoloration of different colors. *Pseudomonas putida* isolated from the contaminated soil is capable of discoloring black ink. The nutrient in the paint contaminated sewage is important in enhancing the deinking process (Maulin, 2017).

Heavy metal detoxification

The sewage from both industrial and demostic influent may contain Cu, Co and Cr (Ebtesam *et al.,* 2013). The bacteria that bioremidating metals includes *Enterobacter*, Enterobacter, Stenotrophomonas, *Providencia, Corynebacterium, Comamonas. Pseudomonas Alcaligenes Arthrobacter Bacillus, Ochrobactrum and Delftia* (Gosa Girma, 2015; Silpa *et al.,* 2015; Ebtesam *et al.,* 2013).

The bacteria employed different mechanisms to detoxify or to survive under metal stressed condition. The general mechanisms include the efflux of metal ions outside the cell, accumulation and complexation of the metal ions inside the cell and reduction of the heavy metal ions to a less toxic state (Richa and Amita, 2016; Viswanathan *et al.,* 2015; Rajesh *et al.,* 2011)

Removal of oil contaminates.

The municipal sewage may contain oil contaminates (TERI, 2014) and scanty of microorganisms use the carbohydrates that found in the oil for their survival (Maulin, 2017)). Each species can degrade limited types of hydrocarbons. For instance, *Methanomonas methanooxidans* can attack only methane, while *Nocardia paraffinicum* and certain species of Pseudomonas can use several hydrocarbons.

The degradation of aromatic compound is carried out by *Pseudomonas stutzeri*, *Pseudomonas mendocina*, *Psudomonas putida* and *P. ovals*. (Hiral and Maulin, 2017).

Removal of halogenated compound

Halogenated compound may be found in solvents, lubricants, intermediates in the synthesis, insulators, plasticizers, etc. bacterial species that participate in dehalogenation are species of *Pseudomonas* and *Xantobacter autophicus* (Hiral and Maulin, 2017).

Role of fungi

Fungi also participate in the municipal sewage treatment and they are versatile in removal of deferent contaminates. Dilna *et al.,* (2011) found that the *Saccharomyces cerevisiae* was able to remove heavy metals such as Pb and Cd from contaminated soil and sewage. Pencillum species were identified for their degrading ability of xenobiotics. They act as biosorbent in removing of xenobitcs (Leitão, 2011). Filamentous fungi such as *Trametes versicolor*, *Pleurotus ostreatus* and *Trichoderma harzianum* were examined for their ability of reducing or removing COD NH_4-N and PO_3-P and show promising result (Hultberg and Bodin, 2017).

Role of protozoa

The predominate protozoa are ciliated groups (https://academic.oup.com) although *Chaeneastricta, Holostichamancoidea and Oxytrichalanceolata* are currently found to be a new species in the waste treatment plant (Martín-Cereceda *et al.,* 2011). Most of these organisms are known to balance the sewage treatment ecosystem (Da Motta, 2011) by feeding on the non-flocculated bacteria.

Role of earthworm

The earthworm species particularly *Eudrillus eugeniae* is found to be important in the conversion of domestic and industrial sewage to usable product. The partially digested organic compound of activated sludge can be converted to caste by action of the earthworm in process called vermocomposting. The formed casting(molded) organic waste can be sieved, dried, tested and then used as biofertilizer (Hemalatha, 2016).

Recommendation

It was showed that the Production of sewage is directly related to the number of population. As the number of population increases, the productions of sewage also increase. Sewage particularly from industrial source is found to be very toxic and may cause a serious illness to human and animals. Currently both the chemical and biological methods are employed. However, the biological methods are showed by different studies to be cost effective, efficient and environmentally friend. Among several microorganisms, bacteria is showed to be highly versatile in treatment of sewage then the others. The role of Microorganisms such as virus, protozoa and algae sewage treatment are remained to be fully unexploited as that of bacteria and fungi. Therefore, further study is needed to discover theirrole these microorganisms in sewage treatment.

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