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Review article

Comparison on efficiency of various techniques in treatment of waste and sewage water – A comprehensive review

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Abstract

In the present scenario, environmental laws have become stringent towards health, economy and reduction of pollution. The pollution is a result of discharge of various organic and inorganic substances into the environment. The sources of pollution include domestic agricultural and industrial water. Conventional techniques such as chemical precipitation, carbon adsorption, ion exchange, evaporations and membrane processes are found to be effective in treatment of waste and sewage water. Recently, biological treatments have gained popularity to remove toxic and other harmful substances. The objective of the paper is to make comprehensive review including the performance of each technique in treatment of waste and sewage water. The research directions are also suggested based on the review.

Keywords: Waste water; Sewage; Conventional treatment; Biological treatment

1. Introduction

Water is one of the most important substances on earth. All plants and animals must have water to survive. If there is no water there would be no life on earth. It covers about 71% of the Earth's surface, and is vital for all known forms of life. But only 2.5% of the Earth's water is fresh water. Rapid urbanization and industrialization releases enormous volumes of wastewater, which is increasingly utilized as a valuable resource for irrigation in urban and peri-urban agriculture. It drives significant economic activity, supports countless livelihoods particularly those of poor farmers, and substantially changes the water quality of natural water bodies [1]. Due to industrialization and urbanization, it is becoming more polluted and risk of this polluted water consumption and its sanitation problem is increasing day to day in most of the developing countries. This growing problem of water scarcity has significant negative influence on economic development, human livelihoods, and environmental quality throughout the world. Hence it has become an essential need for today's environment to protect water from getting polluted or to develop cost effective remedial method for its protection. It is estimated that approximately 1.1 billion people globally drink unsafe water. The World Bank estimates 21% of the communicable diseases, in India, are water related. Of these diseases, diarrhea alone is estimated to have killed over 535,000 Indians in 2004. The major microbial populations found in wastewater treatment systems are bacteria, protozoa, viruses, fungi, algae and helminthes. The presence of most of these organisms in water leads to spread of diseases. The two major chemical pollutants in wastewater are nitrogen and phosphorus. Although there are other chemical pollutants, such as heavy metals, detergents and pesticides, nitrogen and phosphorus are the most frequent limiting nutrients in eutrophication. The various conventional methods for waste water treatment are present since ancient times [2–4] but they are very costly and not economical. The advanced new green technical methods are being introduced to overcome the conventional methods of waste water treatment [4]. The present study is related to new green technical methods which are proving them to be superior over the conventional methods; out of them low cost waste water treatment using microalgae is the potential one. From the literature, it is noted that the new methods of waste water treatment are due to microalgae and they are prone to be efficient in reducing the toxic components. Human development and rapid population growth exert numerous pressures on the quality and access to water resources. This is felt strongest at the interface between water and

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human health; wherein infectious, water borne diseases remain the leading causes of human morbidity and mortality worldwide.

Some techniques deal with reduction of heavy metals whereas other techniques deal with reduction of nitrogen and phosphorus. It is found that the conventional techniques are not efficient in reducing the toxic, heavy metals, nitrogen, phosphorous etc.

There is no unique method to treat most of the compounds in a single step. The main aim of the present paper is to discuss the technological advancements in treatment of waste and sewage water.

2. Background information

Methods of wastewater treatment were first developed in response to the adverse conditions caused by the discharge of wastewater to the environment and the concern for public health. Further, as cities became larger, limited land was available for wastewater treatment and disposal, principally by irrigation and intermittent filtration. Also, as populations grew, the quantity of wastewater generated rose rapidly and the deteriorating quality of this huge amount of wastewater exceeded the self-purification capacity of the streams and river bodies.

Therefore, other methods of treatment were developed to accelerate the forces of nature under controlled conditions in treatment facilities of comparatively smaller size. Although cleanup is necessary to prevent any further discharge of contaminated wastes into the environment, a cost effective technology needs to be developed for industry to use. Traditionally methods employed for wastewater remediation consist of removal of metals by filtration, flocculation, activated charcoal and ion exchange resins [5–7]. In general, from about 1900 to early 1970s, treatment objectives were concerned with: (i) the removal of suspended and floatable material from waste water, (ii) the treatment of biodegradable organics (BOD removal) and (iii) the elimination of disease-causing pathogenic micro-organisms. From the early 1970s to about 1990s, wastewater treatment focused on aesthetic and environmental concerns. The earlier tasks of reduction and removal of BOD, suspended solids, and pathogenic micro-organism were continued, but at larger levels. Removal of nutrients such as nitrogen and phosphorus also began to be addressed, particularly in some of the streams and lakes. Major initiatives were taken around the globe, to achieve more effective and widespread treatment of wastewater to improve the quality of the surface waters. This effort was due to (i) an increased understanding of the environmental effects caused by wastewater discharges and (ii) a knowledge on the adverse long term effects caused by the discharge of some of the specific constituents found in wastewater. Since 1990, because of increased scientific knowledge and an expanded information base, wastewater treatment has begun to focus on the health concerns related to toxic and potentially toxic chemicals released into the environment. The water quality improvement objectives of the 1970s have continued, but the emphases have shifted to the definition and removal of toxic and trace compounds, that could possibly cause long-term health effects and adverse environmental impacts. As a consequence, while the early treatment objectives remain valid today, the required degree of treatment has increased significantly and additional treatment objectives and goals have been added. A typical Dewats system consists of primary and secondary treatments, and disposal (or utilization) of solids and treated water. The primary treatment may be as simple as a septic tank, to remove settleable solids (and provide limited anaerobic treatment), which can be used in areas of poor soil and high groundwater. Modifications of the above system enable aerobic treatment of the effluent and prevent floating solids from entering the secondary treatment. Although cheap and require little maintenance, they are prone to failure and even when operating effectively may still leave a pathogen-rich waste stream. Secondary treatment options, based on sand filters, provide effective removal of pathogens in areas with deep permeable soils, but are ineffective in other locales with highly permeable soil type. There has been a tremendous amount of attention given to the use of biological systems for removal of radio nuclides and heavy metals from solutions. Massoud et al. [8] and Parkinson and Tayler [9] made a comprehensive review on existing treatment methods. All biological-treatment processes take advantage of the ability of microorganisms to use diverse wastewater constituents to provide the energy for microbial metabolism and the building blocks for cell synthesis. This metabolic activity can remove contaminants that are as varied as raw materials and by-products. The content of residual toxic metals in wastewater treatment plants influences the choice of the removal method to be used. Several methods have been applied for final treatment, such as adsorption using activated carbon or other appropriate sorbents, post precipitation, ion-exchange, reverse osmosis, electrochemical treatment and evaporation [10,11].

3. Conventional methods

Conventional methods for removing metals are either becoming inadequate to meet current stringent regulatory effluent limits or are increasing in cost. As a result, alternative, cost effective technologies are in high demand. Conventional techniques for removing dissolved heavy metals include chemical precipitation, carbon adsorption, ion exchange, evaporations and membrane processes [7]. The selection of a particular treatment technique primarily depends on a variety of factors, e.g. waste type and concentration, effluent heterogeneity, required level of cleanup, as well as economic factors. The use of biological materials, including living and non-living micro-organisms, to remove and recover toxic or precious metals from industrial waste waters has gained popularity over the years due to increased performance, availability and low cost of raw materials [12–14], microorganisms including bacteria [15]. Algae [16] and fungi and yeasts [17] can efficiently accumulate heavy metal from their external environment [18–20]. The fundamental reason for the treatment of wastewater is to circumvent the effect of pollution of water sources and protect public health through safeguarding of water sources against the spread of diseases. This is carried out through a variety of treatment systems, which could be onsite treatment systems or offsite treatment systems. This section is therefore aimed at describing the offsite (activated sludge, trickling filters, stabilization ponds, constructed wetlands, membrane bioreactors) wastewater treatment system. All biological-treatment processes take advantage of the ability of microorganisms to use diverse wastewater constituents to provide the energy for microbial metabolism and the building blocks for