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Analysis of Waste Water Treatment

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Abstract
Nowadays many water resources are polluted by anthropogenic sources includinghousehold and agricultural waste and industrial processes. Public concern over theenvironmental impact of wastewater pollution has increased. Several conventionalwastewater treatment techniques, i.e. chemical coagulation, adsorption, activated sludge, have been applied to remove the pollution, however there are still some limitations,especially that of high operation costs. The use of aerobic waste water treatment as areductive medium is receiving increased interest due to its low operation and maintenancecosts. In addition, it is easy-to-obtain, with good effectiveness and ability for degradingcontaminants. This paper reviews the use of waste water treatment technologies to removecontaminants from wastewater such as halogenated hydrocarbon compounds, heavymetals, dyes, pesticides, and herbicides, which represent the main pollutants in wastewater

I. INTRODUCTION

Water, food and energy securities are emerging as increasingly important and vital issues for India and the world. Most of the river basins in India and elsewhere are closing or closed and experiencing moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Current and future fresh water demand could be met by enhancing water use efficiency and demand management. Thus, wastewater/low quality water is emerging as potential source for demand management after essential treatment. An estimated 38354 million liters per day (MLD) sewage is generated in major cities of India, but the sewage treatment capacity is only of 11786 MLD. Similarly, only 60% of industrial waste water, mostly large scale industries, is treated. Performance of state owned sewage treatment plants, for treating municipal waste water, and common effluent treatment plants, for treating effluent from small scale industries, is also not complying with prescribed standards. Wastewater- irrigated fields generate great employment opportunity for female and male agricultural laborers to cultivate crops, vegetables, flowers, fodders that can be sold in nearby markets or for use by their livestock. However, there are higher risk associated to human health and the environment on use ofwastewater especially in developing countries, where rarely the wastewater is treated and large volumes of untreated wastewater are being used in agriculture.

1.1 Water Availability and Use: India accounts for 2.45% of land area and 4% of water resources of the world but represents 16% of the world population. Total utilizable water resource in the country has been estimated to be about 1123 BCM (690 BCM from surface and 433 BCM from ground), which is just 28% of the water derived from precipitation. About 85% (688 BCM) of water usage is being diverted for irrigation (Figure 1), which may increase to 1072 BCM by 2050. Major source for irrigation is groundwater. Annual groundwater recharge is about 433 BCM of which 212.5 BCM used for irrigation and 18.1 BCM for domestic and industrial use (CGWB, 2011). By 2025, demand for domestic and industrial water usage may increase to 29.2 BCM. Thus water availability for irrigation is expected to reduce to 162.3 BCM. With the present population growth-rate (1.9% per year), the population is expected to cross the 1.5 billion mark by 2050. Due to increasing population and all round development in the country, the per capita average annual freshwater availability has been reducing since 1951 from 5177 m3 to 1869 m3, in 2001 and 1588 m3, in 2010. It is expected to further reduce to 1341 m3 in 2025 and 1140 m3 in 2050. Hence, there is an urgent need for efficient water resource management through enhanced water use efficiency and waste water recycling.

1.2 Wastewater Production: With rapid expansion of cities and domestic water supply, quantity of gray/wastewater is increasing in the same proportion. As per CPHEEO estimates about 70-80% of total water supplied for domestic use gets generated as wastewater. The per capita wastewater generation by the class-I cities and class-II towns, representing 72% of urban

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population in India, has been estimated to be around 98 LPCD while that from the National Capital TerritoryDelhi alone (discharging 3,663 MLD of wastewaters, 61% of which is treated) is over 220 LPCD (CPCB, 1999). As per CPCB estimates, the total wastewater generation from Class I cities (498) and Class II (410) towns in the country is around 35,558 and 2,696 MLD respectively. While, the installed sewage treatment capacity is just 11,553 and 233 MLD, respectively thus, overall analysis of water resources indicates that in coming years, there will be a twin edged problem to deal with reduced fresh water availability and increased wastewater generation due to increased population and industrialization. In India, there are 234-Sewage Water Treatment plants (STPs). In class-I cities, oxidation pond or Activated sludge process is the most commonly employed technology, covering 59.5% of total installed capacity Series of Waste Stabilization Ponds technology is also employed in 28% of the plants, though its combined capacity is only 5.6%.

II. WASTE WATER TREATMENT PROCESS

2.1. Conventional methods of treating waste water- The CPCB has studied the functioning of water treatment plants, the prevailing raw water quality and water treatment technology, etc across the country. As per its findings, the following process has been followed by these plants for treating waste water:

(1) Aeration- Aeration involves bringing air or other gases in contact with water to Convert volatile substances from liquid to gaseous state and Dissolves beneficial gases into the water.

(ii)Coagulation and Flocculation: The process of coagulation and flocculation may be broadly described as a chemical/physical process of blending or mixing a coagulating chemical into a stream and then gently stirring the blended mixture. Coagulation- Herein, a coagulant (say, alum) is thoroughly mixed with raw water which causes neutralization of charge of particles. The coagulant chemicals, inorganic and/or organic in nature, when added to water at an optimum dose (normally in the range of 1 to 100 mg/l) cause destabilization.

Flocculation- After coagulation, the water is then flocculated, i.e. it is gently stirred to enhance the contact of destabilized particles and to build floc particles of optimum size, density, and strength to besubsequently removed by settling or filtration.

(iii) Sedimentation and filtration: The flocculated water is then taken to sedimentation tanks / clarifiers for removal of flocs and thereafter to filters where the remaining turbidity is removed.

(iv) Backwashing of filters: As the amount of solids retained in a filter increases, bed porosity decreases. Before they start breaking through the filter, backwashing is required to clean the bed.

(v) Disinfection: Disinfection of potable water system is the specialized treatment for destruction or removal of organisms in water which are capable of causing disease. For such disinfection, the chemical that has been predominantly used is chlorine. This chlorination system consists of six separate subsystems:

- chlorine supply;
- storage and handling;
- safety provisions;
- chlorine feed and application;
- diffusion, mixing and contact; and
- The control system.

2.2. Use of bio-technologies for waste water treatment

According to the CPCB, for treatment of waste water, use of biological methods can be a more cost effective option than use of conventional treatment systems. The bio-technology is less expensive, easy to operate and does not produce secondary pollutants. A few instances of bio-technologies used for treatment of wastes have been described below:

i) Anaerobic technology- The application of anaerobic technology avoids heavy machinery and reduces the land requirement for the waste water treatment plant. The anaerobic process includes the use of the acclimatized microbes for transforming complex macromolecules of organic matter present in waste water into biogas. Also, the stabilized sludge from anaerobic process may be free from strong or foul odors.

The output that it produces, i.e. biogas and digester-sludge can be utilized as an alternate source of energy and as a fertilizer respectively.

ii) Duckweed based waste water treatment- For the purpose of setting up a low cost waste water treatment technology which will also utilize the nutrients in waste water. It has great ability to reduce the suspended solids, bacterial and other pathogens from waste water. As per its findings, this system can be used for small towns or in rural/semi rural areas, where land is available and harvested duckweed can be used for different economic uses.

iii) Enzymatic treatment- Oxidative enzymes such as peroxides are used for removal of toxic

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organic and recalcitrant compounds from drinking water sources as well as from industrial effluents.

iv) Bio-filters- The environmentally sustainable and economically viable biofilters technology uses earthworms and beneficial microbes to break down organic waste present in the waste water and also converts the energy, carbon and other elements of the waste to bio nutritional products such as humus and bio-fertilizer.

III. WASTE WATER USE

Insufficient capacity of waste water treatment and increasing sewage generation pose big question of disposal of waste water. As a result, at present, significant portion of waste water being bypassed in STPs and sold to the nearby farmers on charge basis by the Water and Sewerage Board or most of the untreated waste water end up into river basins and indirectly used for irrigation. In areas like Vadodara, Gujarat, which lack alternative sources of water, one of the most lucrative income-generating activities for the lower social strata is the sale of wastewater and renting pumps to lift it (Bhamoriya, 2004). It has been reported that irrigation with sewage or sewage mixed with industrial effluents results in saving of 25 to 50 per cent of N and Pfertilizer and leads to 15-27 % higher crop productivity, over the normal waters (Anonymous, 2004). It is estimated that in India about 73,000 ha of (Strauss and Blumenthal, 1990) per-urban agriculture is subject to wastewater irrigation. In periurban areas, farmers usually adopt yearround, intensive vegetable production systems (300-400% cropping intensity) or other perishable commodity like fodder and earn up to 4 times more from a unit land area compared to freshwater (Minhas and Samra, 2004). Major crops being irrigated with waste water are:

→ **Cereals:** Along 10 km stretch of the Musi River (Hyderabad, Andhra Pradesh) where wastewater from Hyderabad is disposed-off, 2100 ha land is irrigated with waste water to cultivate paddy. Wheat is irrigated with waste water in Ahmedabad and Kanpur.

→**Vegetables:** In New Delhi, various vegetables are cultivated on 1700 ha land irrigated with wastewater in area around Keshopur and Okhla STPs. Vegetables like Cucurbits, eggplant, okra, and coriander in the summers; Spinach, mustard, cauliflower, and cabbage in the winters are grown at theseplace. In Hyderabad, vegetables are grown in Musi river basin all year round which includes spinach, amaranths, mint, coriander, etc**.**

→ **Flowers:** Farmers in Kanpur grow roses and marigold with wastewater. In Hyderabad, the farmers cultivating Jasmine through wastewater.

→ **Avenue trees and parks:** In Hyderabad, secondary treated wastewater is used to irrigate public parks and avenue trees.

→ **Fodder crops:** In Hyderabad, along the Musi River about 10,000 ha of land is irrigated with wastewater to cultivate paragrass, a kind of fodder grass.

→ **Aquaculture:** The East Kolkata sewage fisheries are the largest single wastewater use system in aquaculture in the world.

→ **Agroforestry:** In the villages near Hubli-Dharwad in Karnataka, plantation trees viz., sapota, guava, coconut, mango, arecanut, teak, neem, banana, ramphal, curry leaf, pomegranate, lemon, galimara, mulberry, etc. are irrigated with waste water.

3.1. Policies and institutional set-up for wastewater management: In addition to setting up treatment plants, Central Government, State Government and the Board have given fiscal incentives to industries/investors to encourage them to invest in pollution control. Incentives/ concessions available to them are:

• Depreciation allowance at a higher rate is allowed on devices and systems installed for minimizing pollution or for conservation of natural resources.

• Investment allowance at a higher rate is allowed for systems and devices listed under depreciation allowance.

• To reduce pollution and to decongest cities, industries are encouraged to shift from urban areas. Capital gains arising from transfer of buildings or lands used for the business are exempted from tax if these are used for acquiring lands or constructing building for the purpose of shifting business to a new place.

• Reduction in central excise duty for procuring the pollution control equipments.

• Subsidies to industries subject for installation pollution control devices.

• Rebate on cuss due on water consumed by industries, if the industry successfully commissions an effluent treatment plant and so long as it functions effectively.

• Distribution of awards to industries based on their pollution control activities.

• Amount paid by a tax payer, to any association or institution implementing programmers for conservation of natural resources, is allowed to be deducted while computing income tax. Customs duty exemption is granted by the Central Government for items imported to improve safety and pollution control in chemical industries**.**

IV. PRACTICE ON DIFFERENT ASPECTS OF WASTEWATER:

4.1. Bio-refineries wastewater treatment -Bio-refineries for the production of fuel ethanol produce large volumes of highly polluted effluents. Anaerobic digestion is usually applied as a first treatment step for such highly loaded wastewaters. At present, the anaerobic biological treatment of biorefinery effluents is widely applied as an effective step in removing 90% of the Chemical Oxygen Demand (COD) in the effluent stream. During this stage, 80– 90% BOD removal takes place and biochemical energy recovered is 85–90% as biogas (Pant and Adholeya, 2007; Satyawali and Balakrishnan, 2008). To reduce the BOD to acceptable standards, the effluent from an anaerobic digestion step requires further aerobic treatment. However, biological treatment processes alone are not sufficient to meet tightening environmental regulations (Pant and Adholeya, 2007).A proper choice of tertiary treatment can further reduce color and residual COD. Yet another approach is to use algae. The advantage of wastewater treatment using algae is that one can reduce the organic and inorganic loads, increase dissolved oxygen levels, mitigate CO2 pollution and generate valuable biomass by sequential use of heterotrophic and autotrophic algal species and the generated biomass can be an excellent source of 'organic' fertilizers. This particular aspect of algae can help remediate highly polluted wastewaters.

4.2. Municipal wastewater treatment using constructed wetlands -Constructed wetlands (CWs) are a viable treatment alternative for municipal wastewater, and numerous studies on their performance in municipal water treatment have been conducted. A good design constructed wetland should be able to maintain the wetland hydraulics, namely the hydraulic loading rates (HLR) and the hydraulic retention time (HRT), as it affects the treatment performance of a wetland (Kadlec and Wallace, 2009). Indian experience with constructed wetland systems is mostly on an experimental scale, treating different kinds of wastewater (Juwarkar et al., 1995; Billore et al., 1999, 2001, 2002; Jayakumar and Dandigi, 2002). One of the major constraints to field-scale constructed wetland systems in developing countries like India is the requirement of a relatively large land area that is not readily available. Subsurface (horizontal/ vertical) flow systems, generally associated with about a 100 times smaller size range and 3 times smaller HRTs (generally 2.9 days) than the surface flow systems (with about 9.3 days HRT, Kadlec, 2009), are therefore being considered to be the more suitable options for the developing countries. Shorter HRTs generally translate into smaller land requirement. Batch flow systems, with decreased detention time, have been reported to be associated with lower treatment area and higher pollutant removal efficiency (Kaur et al., 2012a, b). Thus, batch-fed vertical sub-surface flow wetlands seem to have an implication for better acceptability under Indian conditions.

4.3. Wastewater application methods - Farm workers and their families practicing furrow or flood waste water irrigation techniques are at the highest risk. Spray/sprinkler irrigation leads to the highest potential deposit of the salts, pathogens and other pollutants on the crop surfaces and affects nearbycommunities. Drip irrigation is the safest irrigation method but suffers from clogging of the emitters, depending on the wastewater total suspended solid concentrations. Use of appropriate filters such as gravel, screen and disk filters in combination with drip systems has been observed to tremendously reduce the clogging and coliform incidence.

4.4. Post-harvest interventions -Postharvest interventions are an important component for health-risk reduction of wastewater-irrigated crops and are of particular importance to address possible on-farm pre-contamination, and also contamination that may occur after the crops leave the farm. The health hazards could be markedly lowered with adoption of some of the low cost practices such as repeated washings, exposure of the produce to sunlight and raising the crops on beds, removing the two outmost leaves of cabbage and also, cutting above some height from ground level. 5. BENEFITS The water treatment process does not only produce clean reusable water, but also has the potential to produce various other benefits. It has the potential to reduce a country's waste production, to produce energy through methane harvesting, and the potential to produce natural fertilizer from the waste collected through the process. Below is a more detailed explanation of these benefits:

5.1. Waste Reduction: Through the treatment of wastewater, the amount of waste that is usually released into the environment is reduced thus improving environment's health. By doing so, the government in turn reduces the health risks

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associated with environmental pollution, and reduces the water loss induced through water pollution. Wastewater treatment also reduces the amount of money spent by a country on environmental rehabilitation projects required to battle pollution.

5.2. Energy Production: The sludge collected during the treatment process isitself treated because it contains a large amount of biodegradable material. It is treated with anaerobic bacteria in special fully enclosed digesters heated to 35 degrees Celsius, an area where these anaerobic microorganisms thrive without any oxygen. The gas produced during this anaerobic process contains a large amount of methane, which is harvested and then burned to generate electricity. This energy can be used to power the wastewater treatment plants making them selfsustainable, and if there happens to be an excess of energy produced, it could be transported into a country's national grid. This helps lower the reliance on nonrenewable energy sources such as fossil fuels, reducing a country's carbon footprint and a country's expenditure on energy production. An example of this system being used within the Middle East can be found in al-Samra wastewater treatment plants in Jordan. According to government officials the plant produces 40% of the energy it requires through burning the methane produced by the treatment process.

5.3. Fertilizer Production: Any biodegradable material remaining is dried in "drying lagoons" and is then turned into natural fertilizer. The resulting natural fertilizer is then used in the agricultural sector, increasing crop yields. This decreases the use of chemical fertilizers that pollute the surrounding marine and surface ecosystems.

6. CONCLUSIONS In developing countries like India, the problems associated with wastewater 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 wastewater dependent livelihoods and on the other hand protect degradation of our valuable natural resources. The use of constructed wetlands is now being recognized as an efficient technology for wastewater treatment. Compared to the conventional treatment systems, constructed wetlands need lesser material and energy, are easily operated, have no sludge disposal problems and can be maintained by untrained personnel. Further these systems have lower construction, maintenance and operation costs as these are driven by natural energies of sun, wind, soil, microorganisms, plants and animals. Hence, for planned, strategic, safe and sustainable use of wastewaters there seems to be a need for policy decisions and coherent programs encompassing low-cost decentralized waste water treatment technologies, bio-filters, efficient microbial strains, and organic / inorganic amendments, appropriate crops/ cropping systems, cultivation of remunerative non-edible crops and modern sewage water application methods.