Domestic water treatment – an Indian perspective

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Abstract: Water scarcity in India is increasing in an astronomical rate. More than 50% of the population is experiencing water stress. Domestic waste water (inclusive of kitchen waste and bathroom waste) treatment plays a crucial role in treating the waste water and reuse it for recreational and agricultural activities. But in India, less than 50% of sewage water is only treated and the rest is disposed untreated. This untreated water pollutes the water bodies and may lead to adverse effects on aquatic life and also water quality. This paper reviews the various domestic waste water treatment plants, their advantages and limitations. Based on the literature, the study proposes a cost effective waste water treatment method.

Keywords: Water stress, water management, waste water treatment, renewable energy, solar.

1. Introduction:

Water makes this planet fit for life. But astronomical increase in population and unsustainable usage of water has created water stress across the globe and countries are striving to mitigate water stress by adopting sustainable water management practices. One such practice is waste water treatment. But the existing waste water treatment processes are expensive, in terms of operational cost, capital cost and maintenance cost, releases greenhouse gases and also high energy consuming. This paper attempts to explore and investigate the extant waste water treatment plants and also to review the innovative water treatment plants. The new methodologies include use of solar energy, wind energy, bio gas, bio filtration, bio-flocculation and biofilms.

2. Literature Review:

2.1 Water Stress:

Water, the essence of life, distinguishes planet earth from other planets and makes it fit for life. Though we are surrounded by water, only 3% is available as fresh water which caters to the needs of domestic purposes, agriculture, and industrial usage and so on. The proper consumption and utilization of available water with judicial distribution among the consumers and also maintaining the
water bodies are the need of the hour. But population explosion, rapid industrialization and consequent urbanization, complex water consumption patterns, improper water resources management, monsoon failure and climate change are increasing the water stress in India. Around 54% of Indian population are affected by water stress [1] which is a consequence of increasing demand and poor quality of water [2]. India is among the 17 extremely water stressed countries and is ranked 13 in 2019 [3, 4]. The technological advancements increases the anthropogenic alteration of nature which directly and indirectly affects the environment especially the water resources. World Economic Forum’s survey (2015) assessed the potential global risks and a water crisis is identified to top the list [5] Another study by United Nations World Water Assessment Programme [6] warned the global community of unprecedented natural calamities in view of unsustainable usage of water. Further it is estimated that by 2050, global population expected to be 9 billion and there will further increase by 40% in water requirements [7].

2.2 Water Management:

Systematic and scientific way of water management is the only salvation to manage the above said water stress. Direct methods of water management are sustainable usage of water and water bodies’ management. Similarly, water saving plays a crucial role in water management such as rainwater harvesting, groundwater harvesting, modern irrigation methods etc. Another major contributor is waste water treatment. Waste water refers to all types of waste from industries, agricultural runaways, domestic grey water and domestic sewage water. The domestic sewage water (inclusive of domestic grey water) include organic, inorganic, oil/grease impurities and microbial contamination as given in Figure 1. The sewage water can be treated for their biological contaminant removal such as trickling filters, activated sludge process, Extended aeration process, constructed wetland systems, Rotating or moving bed bio-reactors and so on.

Figure 1: Domestic Sewage Water

2.2.1 Industrial Effluents:

Kaur et al [8] reported that around 15000 MLD of industrial effluents are generated of which 60% is treated before disposal. But since the cost of installing effluent treatment plants by micro and small companies is high, CPCB has established common effluent treatment plants (CETP) in 2005 [9]. Indian Government has taken some milestone initiatives to curb the release of untreated industrial waste water into water bodies such as Namami Gange Program and Zero liquid discharge model [10]. The zero liquid discharge ensures that the industries recycle their waste water and use them further in
their processes. Interestingly, India’s industrial effluent treatment market is projected to be $2.3 bn in 2022 [11]

2.2.2 Domestic grey water treatment:

Grey water is the waste water generated from showers, kitchen sinks and washing machines [12]. This water is rich in total nitrogen and total phosphorous content[13] which will lead to eutrophication which when disposed to the water bodies untreated, may lead to a negative impact on aquatic organisms. Also, they may contain organic washaways or oil / grease or hazardous pollutants which may adversely affect the environment.

Karnapa a [14] reported that around 70-90 litres of grey water is generated by a normal Indian household. Manna S [15] studied various grey water treatment methodologies such as screening, sedimentation, wet land construction, filtration, disinfection etc. Samayamanthula et al [16] analysed several methods of effective utilisation of greywater for sustainable water management. The study reported simple less-expensive gravity governed sand filtration and disinfection for grey water treatment which showed comparable results with other grey water treatment techniques. But in India, the practice of segregating grey water and sewage water is minimal or abysmal.

![Figure 2: Sustainable Water Management](image)

2.2.3. Sewage Water Treatment:

Process of removing all contaminants from domestic waste water is called sewage water treatment. The general process involved is given in Figure 3. The resultant effluent and the treated sludge may be used suitably.

![Figure 3: Sewage treatment process](image)
Singh A et al [17] reported the process of sewage water treatment in a Goa plant. Most commonly used technologies in Goa include EA (extended aeration) and Sequencing batch reactor and in some of the plants use moving bed bio reactors. Jamwal and Mittal [18] examined the suitability of reusing STP based on microbial evaluation with specific reference to 17 STPs in Delhi. The STP process followed is as given in Figure 3. The treated water is used for agriculture, horticulture and for recreation purposes. The authors recommended the tertiary treatment for reusing water for consumption without any health hazard.

Chiu et al [19] analysed the municipal waste water treatment feasibility and its reuse for secondary uses such as cleaning, flushing and industrial use. The authors recommended the installation of treatment plants to augment the water requirement in Taiwan. Similarly, Japan has installed water treatment plants in major cities to alleviate water stress owing to climate changes and reused the treated water for secondary operations [20]. Apostolidis, N et al, [21] reported the success story of community support to reuse of recycled water for non-potable purpose. The 40 year journey of Australian involving community participation and their support for the use of water treatment plants was tremendous. The paper further presents the various wastewater treatment plants and the applications of recycled water. Pinjing et al [22] reported that waste water reclamation in China for potential urban and industrial use. China’s water pollution and water scarcity problems have led to the establishment of water reclamation projects. Barbagallo et al [23] ascertained the waste water reclamation as a viable solution to mitigate water pollution and also to reuse for irrigation in Italy.

The studies presented above establishes the fact that sewage water (municipal waste water) treatment offers a potential solution to reduce water pollution and to meet the increased water demand. Albeit its significance, the conventional treatment processes involve heavy capital, operational and maintenance costs. Also the electricity consumption is very high. According to a study conducted by UN-water activity information systems, a 300 MLD treatment plant costs around INR 300 Crores. Energy consumption of a 200 MLD is around 1 MW [24]. In this paper, the cost effective sewage water treatment plant with solar power is presented which may be a game-changer in the field of waste water reclamation.

2.2.4. Solar powered waste water treatment plant:

In India sewage generated is estimated to be 72,368 MLD and 1469 sewage treatment plants are installed with a total capacity of 31848 MLD [25] It implies that more than 50% of the sewage water is untreated. Some of the installed plants are non-functional owing its huge maintenance cost. The energy consuming treatment process may be replaced with renewable energy powered processes. Coffey [26] reported the use of renewable energy such as solar and wind power for ultrafiltration membrane technology, in waste water treatment plants in Atlanta, USA. Many plants in USA have successfully integrated renewable energy like solar, wind, biogas etc for filtration processes. Use of solar power for waste water treatment in Brazil was reported by Marcelino et al [27]. This study involved the use of advanced oxidation process (for the removal of harmful pollutants) with solar radiation. The process was proved to be effective in the decontamination of waste water in an eco-friendly way.

Ortiz, N., (2018) investigated the removal of amoxicillin from domestic waste water which poses threat to the aquatic life using solar decomposition in Brazil. The process is done in two stages, viz., and decomposition of pollutants using solar energy followed by biosorption using biocarbon. The process was reported to remove the toxic sludge treatment step in the water treatment process. Status of 105 solar powered waste water treatment plants of California was reviewed by Strazzabosco et al [29]. Of the 105 plants, 41 plants have installed renewable energy for waste water treatment. The authors investigated the extent of energy demand offset by solar and biogas. It was reported that on an average 1MW contribution of energy was by solar energy that is 8-30% of energy demand is augmented by the use of solar PVs.

Igoud et al [30] analysed the waste water treatment plants in Algeria and reported that conventional treatment processes are highly energy consuming and accounted for huge carbon emission. The authors carried out waste water treatment experiments in a laboratory with few select samples using
solar energy (SOWAT). The experimental results revealed that the use of solar energy provided a sustainable waste water treatment without any electricity consumption and carbon emission. Also, the SOWAT resulted in effective removal of pollutants from waste water. The above studies revealed that sewage water treatment (Waste water treatment) is crucial for combating water stress and to mitigate water pollution in a sustainable way. The use of renewable energy makes the process more eco-friendly and less energy consuming. Hence, this study proposes the following method for sewage water treatment in India.

Sehar S and Naz (2016) reported the use of biofilms for wastewater treatment which will simplify the conventional multi-step biological treatment. The micronutrients on the biofilms will degrade the pollutants effectively and can directly be reused for agriculture or recreational activities.

3. Proposed Methodology

Based on the review the following two methodologies are proposed for the Indian context. The first method uses bioflocculant and solar energy for waste water treatment. The schematic representation of the methodology is given in Figure 4. The process involved starts with the removal of bulk impurities by screening process. Water then flows through filters for the removal of grit. Bioflocculants (which are commercially available may be used) which will remove the suspended impurities. Then the water can be aerated for the removal other oxidisable impurities and are passed through biofilms. The aeration tank utilizes compressed air which is solar powered. The biofilms will remove biological impurities and the treated water can be used directly for agriculture or other activities.

Figure 4. Proposed sewage treatment process

Advantages of the suggested process include the use of solar power for aeration. The high energy consumption processes in conventional waste water treatment are aeration and biological treatment. Since solar power is used for aeration and biofilms are used for microbial contamination removal, the energy consumption may considerably be reduced.

4. Conclusion

The population explosion and industrialization have resulted in water stress across the globe. India is affected to large extent. Various strategies have been adopted to mitigate the water stress such as water resources management and waste water treatment. Waste water treatment is adopted by many countries. It was reported that conventional sewage water treatment plants are expensive with high energy consumption. New technologies have been developed with renewable energy, biosorption, bioflocculants and biofilms for making the process cost effective. One such process of solar powered waste water treatment with bioflocculants and biofilters are suggested for India.

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