International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-10, Issue-6, December 2023
https://doi.org/10.55524/ijirem.2023.10.6.11
Article ID IJIRD-1306, Pages 72-77
www.ijirem.org

# Wastewater Treatment for Water Reclamation and Reuse

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**ABSTRACT-** Srinagar, located in the Kashmir Valley, faces significant water scarcity challenges due to population growth, urbanization, and limited freshwater resources. Though the valley is known for its rich water resources, the main city still faces significant water challenges that impact its environment, economy, and social well-being. In this context, wastewater treatment plays a crucial role in reclaiming and reusing water to address the city's water security concerns. This thesis focuses on exploring wastewater treatment technologies and strategies specific to Srinagar, Kashmir. The cost of reclaimed wastewater relative to other water sources and public acceptance of the reclaimed wastewater are the two main factors that determine the viability of wastewater reuse. For social efficiency, the choice of wastewater treatment must weigh a variety of factors and determine which combination will provide the highest net benefit. Presently 3 STP's namely Hazratbal STP, Laam STP, and Habak STP are functioning around Dal Lake under the control of LCMA (Lake Conservation and Management Authority) and these 3 STP's discharged the treated water in the Dal Lake. This thesis also focuses on saving the beautiful Dal Lake by diverting the treated wastewater from STP's around the Dal Lake for non-portable use like irrigating fields, landscape irrigation (public parks, playgrounds, green areas etc.), street cleaning, fire protection system, vehicle washing etc. In this study the water samples from the inlet and outlet of all three plants were analyzed for a duration of three months (May, June, July) for various parameters like Temperature, Dissolved oxygen, BOD, COD, TSS, Phosphorous, Nitrogen content etc. in order to check its quality and usability for non-portable purposes. The quality of the effluent was compared with the standards. The results demonstrate that COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), TSS (Total suspended solids) and Faecal Coliforms have reduced enough according to CPCB (Central Pollution Control Board) and USEPA (United States Environmental Protection Agency) that this wastewater coming out of all three plants has no restrictions for use in agriculture but some parameters haven't decreased enough to be used for landscape irrigation, street cleaning etc. This study, therefore, tries to attract the attention of the concerned stakeholders for a relook at the purpose of increasing the efficiency by employing the most competent and technical people so that the same treated water can be used for all non-portable purposes.

**KEYWORDS-** BOD, COD, Dissolved Oxygen, Faecal Coliforms, Fluidized aerobic bio-reactor, Nitrogen, Phosphorous, Polyaluminum chloride, Sodium hypochlorite.

## I. INTRODUCTION

Global population growth, rising per capita consumption and the needs of the industrial and agricultural sectors are the main causes of the rising demand for freshwater. This tremendous demand for freshwater is a serious problem, especially in water-scarce regions. Out of many alternatives there, reclaiming wastewater could be the reliable option to maintain a balance between supply and demand. Reclaimed domestic wastewater reuse has recently become more popular as a potential non-traditional supply to meet the water's rising demand [1]. Wastewater must be properly treated to avoid health hazards and environmental damage, which is directly related to rising water usage. Since several activities do not require water of potable quality, reuse of reclaimed water and nutrient recycling may be substituted for conventional resources. Treated wastewater effluents may be reused for different purposes such as landscape irrigation (parks, green areas, golf courses, etc.), recreational activities, firefighting, reclamation of urban streams and rivers, groundwater recharge, and industrial uses [2][3][4][5].

Unclean water contributes to 1.7 million deaths worldwide each year, with over 90% of those deaths occurring in underdeveloped nations and almost half are children. It also increases the risk of opportunistic diseases, diarrhea, and malnutrition. So, it is very dangerous to use untreated wastewater for non-portable purposes or discharge it directly into the water body. Therefore, wastewater must be treated before releasing it into the environment. Studies have shown that sewage treatment processes change the physicochemical parameters of the final effluent such as dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity, alkalinity, total hardness, some metals, and non-metal ions [6]. Additionally, purifying procedures eliminate pathogenic bacteria [7]. Different studies have evaluated the efficiency of STPs and have compared the concentration of the chemical in the influent and that in the effluent. Most studies have found that there is a large reduction at the STP outflow sites [8]. Nevertheless, several investigations have revealed a minimal or nonexistent decrease in pollutant levels [9].

The largest union territory of India, Jammu and Kashmir has always had abundant water resources but a city like

Srinagar is still facing water scarcity. One of the reasons is an increased population which has led to more water demand. According to the study, 80% of the same demand is converted into wastewater which in the end is discharged into water-bodies either treated or untreated. Only 30% of city's land is sufficiently covered by sewage systems, according to the Srinagar city development plan (SCDP). The comptroller and auditor general of India claim that the government permitted irrigation canals in J&K to become sewer drains (CAG, 2011). Srinagar has five sewage treatment plants with a combined capacity of 32.2 MLD, compared to the city's overall sewage generation of 195 MLD [10]. Out of the five STPs, the present study was carried out on only three STPs namely Hazratbal STP, Laam STP, and Habak STP. All the STPs located on the shores of Dal Lake use fluidized aerobic bioreactor (FAB) technology for the treatment which is an improved substitute for conventional wastewater treatment plants. A fluidized aerobic bioreactor comprises a tank filled with specially created media made of unique material and of suitable density that can be fluidized using an aeration device through diffusers. The bio-film that develops on the media moves along the effluent in the reactor. This thin film on the media enables the bacteria to act upon the biodegradable matter in the effluent and reduce BOD/COD content in the presence of oxygen from the air used for fluidization.

The treated sewage of the city coming out of the treatment plants is discharged into Dal Lake while the city has the potential to use the treated waste-water for non-potable purposes specifically in irrigation. The most effective technique to utilize wastewater may be to reuse effluent for irrigation purposes since it is a renewable and highly reliable resource. Because wastewater treatment systems are generally capital-intensive and expensive, the reuse of treated wastewater in irrigation may provide various benefits which have the potential to offset the cost of treatment. The amount of plant nutrients in the effluent, particularly the amounts of nitrogen and phosphorus, can have a significant role in reducing fertilizer expenditures. Reusing wastewater has increased crop yields by 10 to 30 percent and has been successful in irrigating a variety of crops. The cost of reclaimed wastewater relative to other water sources and public acceptance of the reclaimed wastewater are the two main factors that determine the feasibility of wastewater reuse.

## II. LITERATURE REVIEW

According to a recent report, the city had issues with the production and handling of sewage. The government and other stakeholders face a dilemma as a result of the increased sewage generation and decreased sewage treatment. Due to its expanding population and urbanization, the city generated a huge amount of sewage. The majority of Srinagar's sewage production was attributable to residential sources, including homes, businesses, and organizations[1]. The city's sewage system was unable to keep up with the growing amount of sewage produced as it grew. This led to insufficient sewage collection and treatment, which raised issues with the environment and public health. As per the census 2011 the population of two Capital cities of Srinagar & Jammu is 19.85 lakh[2]. The present sewage generation is 255.41 MLD and will go up to 461.80 MLD for design year 2044. With regard to Srinagar, one of the most picturesque cities, there is a population of 12.03 lakh and a sewage generation of 195 MLD. According to the Central Pollution Control Board (CPCB), 85 liters per capita per day (LPCD) of wastewater provided to any household is currently released back in the form of sewage. With an increasing population consuming water and decreasing wastewater recycling and reuse in the municipal sector, this is expected to rise to 121 LPCD by 2030[3].

Only 30% of the territory of Srinagar is covered by adequate sewerage systems, and only 12% of houses have access to sewer connections, according to the Srinagar City Development Plan (SCDP) (JKERA 2007). Srinagar has 5 sewerage treatment plants with a combined capacity of 32.2 MLD, compared to the city's overall sewage generation of 195 MLD. Ultimately, rivers, lakes and canals downstream of the city receive both treated and untreated sewage water[4]. Three of the five STPs are located along the shores of Dal Lake. These three STPs are Hazratbal STP (7.5 MLD capacity), Laam STP (4.5 MLD capacity), and Habak STP (3.2 MLD capacity). All three STPs have a 15.2 MLD capacity, which is far too little for a city like Srinagar which is generating ten times more sewage compared to its capacity. The wastewater from these three STP's are dumped into Dal Lake which is heart of the city and is one of the most visited places in Srinagar by locals and tourists. But due to heavy disposal of sewage into it, Dal has lost its charm. Due to the wastewater being disposed of into it, the Dal Lake has suffered significant damage[5]. The lake's water quality has significantly declined as a result of ongoing garbage discharge. The water's oxygen content has decreased from 10.2 mg/liter to 6.8 mg/liter. Dissolved solids like nitrogen and phosphorus have increased, going from 30.2 mg/liter to 200 mg/liter[6]. The lake's water has turned green in some areas due to the proliferation of algae which has led to eutrophication of a lake as shown in Figure 2. In the past 20 years, the lake has decreased in size from its former 75 square kilometers to just 12 square kilometers. The lake's depth has also decreased by around 12 meters, which is a serious indication of the risks the lake confronts.

Figure 2: Eutrophication of Dal Lake

## III. MATERIAL AND METHODOLOGY

The current study was conducted on three Sewage treatment plants (STP's) that are located on the shores of Dal Lake. The three STP's are Hazratbal STP, Laam STP and Habak STP as shown in Figure 1. These 3 STPs utilize FAB technology to treat the wastewater, and after treatment, the wastewater is discharged straight into Dal

Lake. In order to investigate the physicochemical parameters of treated sewage, six sampling points were selected which include site 1 at Hazratbal, site 2 at Laam and site 3 at Habak. Water samples have been collected from both inlet and outlet chambers of treatment plants to determine the efficiency of plants and to determine the parameters of treated wastewater. Water samples have been collected in plastic bottles of 1 litre capacity and were carried to the laboratory for detailed analysis. The analysis was done as per the standard methods given in American Public Health Association (APHA).

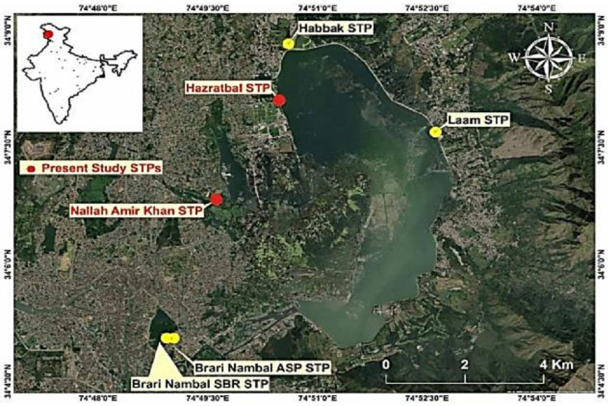


Figure 1: Location of Various STP's Around Dal Lake

The parameters were monitored at all the six locations for a period of three months (May-July) in plastic bottles which were rinsed with distilled water. The parameters like pH, and temperature were checked on spot with a multi-parameter probe calibrated with standard solutions. Titrimetric method was used to determine Total Alkalinity (TA), Chloride content ($Cl^-$) and Dissolved Oxygen (DO). COD was determined by Open reflux method while BOD was determined by 5-day incubation method and sewage dilutions at a ratio of 5:100 (5%) were prepared. The removal efficiency for physiochemical parameters were calculated as

$$Removal\ Efficiency(\%) = \frac{Influent\ Conc. - Effluent\ Conc.}{Influent\ Conc.} * 100$$

For microbial examination, samples were examined as soon as possible after collection. A multiple tube fermentation technique or most probable number (MPN) technique was used to determine the bacterial indicators as faecal coliforms (FC) and faecal streptococci (FS) according to standard methods described in APHA. Multiple tube fermentation method used in the present work included measurement of total plate count and MPN of coliform. Bacterial indicators removal efficiency was calculated as

$$Removal\ Efficiency(\%) = \frac{log\ \ CFU\ in\ Influent - log\ \ CFU\ in\ Effluent}{log\ \ CFU\ in\ Influent}$$

## IV. RESULTS AND DISCUSSIONS

As evident from the data, mean value of temperature has increased from influent to effluent in all three STP's. Temperature plays an important role in decomposition of organics. More the temperature, the more is the rate of decomposition. The survey of various treatment processes in wastewater treatment shows that temperature is an important factor affecting efficiency of settling and flocculation. The temperature of wastewater becomes extremely important in certain wastewater unit operations such as sedimentation tanks and re-circulating filters.

The present investigation reveals that mean value of pH increased from influent to effluent but is within permissible limits. Usually, sewage is acidic to a degree, but it depends on the specific effluents being conveyed by the sewer. Phosphorus and Nitrogen being nutrients are very essential for the plant growth which means the same water if used in agricultural fields can lead to reduction in the use of fertilizers but can also retard the growth of crops if these are in excess. Also, the wastewater containing excess phosphorus and nitrogen if disposed of in lake can lead to the eutrophication of lakes. The investigation reveals phosphorous is within limits according to CPCB but is exceeding the Indian discharge standards (1mg/L). Similarly, the value of nitrogen is within limits according to CPCB but is exceeding according to Indian discharge standards (1mg/L). Ammoniacal nitrogen is in excess according to EPA also. In all three STP's chemicals are being used to reduce the nutrients like PAC (poly aluminum chloride) which acts as a coagulant. Surprisingly the concentration of phosphorous subjected to the treatment of PAC in the treatment facility did not yield the desired results. The possible problem actually is not to use the right type of dosage of PAC and not to provide optimum contact time for complete precipitation of phosphorus from the sewage.

Dissolved oxygen is an important parameter for estimating the pollution level due to organic matter and determines physical as well as biological activities like decomposition of organics in water [11]. Due to prevailing septic conditions, and flow of sewage through closed sewer lines resulted in low DO conditions in the raw [12]. Aquatic life has an acceptable DO standard of 4–5 mg/L while the concentration of DO in the effluent was much below the recommended limits of USEPA (6-9mg/l), thus posing potential danger to receiving water body [13]. Additionally, low dissolved oxygen levels increase the toxicity of a number of substances, posing a concern if the same water is reused. BOD5 in the influent was contributed from domestic wastes effluents from households. Organic matter present in the waste is oxidized by microbes present in the bioreactor resulting in decrease in BOD. The evaluation revealed a gradual decrease in BOD of the effluent as the sewage was subjected through aeration in FAB I and II. Values of BOD5 in the effluent were within the limits according to CPCB (30mg/l) and USEPA (30mg/L) discharge standard if the wastewater is to be disposed in a lake or to be used for irrigation but is not within permissible limits according to USEPA (10 mg/L) if the effluent is to be used for urban reuse. COD in wastewater is due to organic as well as inorganic compounds in the wastewater representing oxygen depleted per liter (Faisal et al., 2020). Values of COD in the raw were higher than BOD which is an indication of the presence of some amount of inorganic substances in the domestic wastewaters.

However, its reduction in the effluent could be attributed to the aeration and decomposition process taking place during treatment with significant variation. COD values in the effluent were within permissible limits according to CPCB (250 mg/L) as well as USEPA (90 mg/L). The results also show the value of faecal coliforms are within permissible limits according to CPCB (1000 FC/100 ml) and USEPA for irrigation (1000FC/100 ml) for Hazratbal STP as shown in table 1 and Laam STP as shown in table 2 but is not within permissible limits for Habak STP as shown in table 3. The reason for that is poor quality of sodium hypochlorite (NaOCl). Also, the value is not within permissible limits according to CPCB for urban reuse (No FC/100 ml) as well as according to FAO (less than 200FC/100 ml).

Table 1: Results of Various Physiochemical Parameters of Sewage at Inlet and Outlet of Hazratbal Stp In Year 2023-24 along with Discharge Standards

| Parameters | Mean (May, June, July) of raw influent | Mean of treated effluent | Removal Efficiency | Permissible Limits | |
|---|---|---|---|---|---|
| | | | | CPCB | EPA |
| Water Temperature (◦C) | 19.0 | 19.3 | _ | _ | _ |
| pH | 7.1 | 7.3 | _ | 5.5-9 | 5.5-9 |
| T-phosphorous (mg/L) | 3.0 | 1.2 | 60% | 5.0 | _ |
| Ammonical Nitrogen (mg/L) | 17.4 | 13.1 | 24.7% | 50 | 5 |
| Nitrate Nitrogen (mg/L) | 0.6 | 0.9 | _ | _ | 15 |
| T.S.S (mg/L) | 243.4 | 39.3 | 83.8% | 100 | 45 |
| Fecal Coliform (Col/100mL) | _ | 1000 | _ | Less than 1000 | 1000 |
| Dissolved Oxygen (mg/L) | 0.4 | 3.3 | _ | _ | 6-9 |
| COD (mg/L) | 275 | 92.3 | 66.4% | 250 | 90 |
| BOD (mg/L) | 146.33 | 28 | 80.86% | 30 | 30 |

Table 2: Results of Various Physiochemical Parameters of Sewage at Inlet and Outlet of Laam Stp In Year 2023-24 along with Discharge Standards

| Parameters | Mean (May, June, July) of raw influent | Mean of treated effluent | Removal Efficiency | Permissible Limits | |
|---|---|---|---|---|---|
| | | | | CPCB | EPA |
| Water Temperature (◦C) | 19.2 | 19.5 | _ | _ | _ |
| pH | 7.1 | 7.6 | _ | 5.5-9 | 5.5-9 |
| T-phosphorous (mg/L) | 1.8 | 1.0 | 44.4% | 5.0 | _ |
| Ammonical Nitrogen (mg/L) | 10.1 | 7.7 | 23.7% | 50 | 5 |
| Nitrate Nitrogen (mg/L) | 0.9 | 1.2 | _ | _ | 15 |
| T.S.S (mg/L) | 164.3 | 31.6 | 80.7% | 100 | 45 |
| Fecal Coliform (Col/100mL) | _ | 716.6 | _ | Less than 1000 | 1000 |
| Dissolved Oxygen (mg/L) | 0.7 | 4.0 | _ | _ | 6-9 |
| COD (mg/L) | 219.6 | 66 | 69.9% | 250 | 90 |
| BOD (mg/L) | 121 | 22.3 | 81.57% | 30 | 30 |

Table 3: Results of Various Physicochemical Parameters of Sewage at Inlet and Outlet of Habak Stp In Year 2023-24 along with Discharge Standard**s**

| Parameters | Mean (May, June, July) of raw influent | Mean of treated effluent | Removal Efficiency | Permissible Limits | |
|---|---|---|---|---|---|
| | | | | CPCB | EPA |
| Water Temperature (°C) | 19.0 | 19.4 | _ | _ | _ |
| pH | 7.0 | 7.4 | | 5.5-9 | 5.5-9 |
| T-phosphorous (mg/L) | 2.7 | 1.5 | 44.4% | 5.0 | |
| Ammonical Nitrogen (mg/L) | 17.1 | 14.6 | 14.6% | 50 | 5 |
| Nitrate Nitrogen (mg/L) | 0.8 | 1.1 | _ | _ | 15 |
| T.S.S (mg/L) | 259.3 | 74.6 | 71.2% | 100 | 45 |
| Fecal Coliform (Col/100mL) | _ | 1266.6 | _ | Less than 1000 | 1000 |
| Dissolved Oxygen (mg/L) | 0.4 | 3.0 | _ | _ | 6-9 |
| COD (mg/L) | 360.3 | 96.6 | 73.1% | 250 | 90 |
| BOD (mg/L) | 180 | 30 | 83.33% | 30 | 30 |

## V. CONCLUSION

It was observed that most of the parameters in the wastewater were reduced within permissible limits according to CPCB and USEPA (for irrigation) which means the treated water from all three STP's can be used for irrigation purposes but for the distribution of that treated water there is a need for separate and efficient conveyance system to transport treated water to agricultural canals. Also, the value of faecal coliforms comes out to be more according to USEPA for urban reuse (NO FC/100ml) which means the same treated water can't be used for landscape irrigation as of now. The reason for the high value of faecal coliform, in that case, is the use of poor quality of sodium hypochlorite (disinfectant) and inadequate dosage. To make the same water usable for every non-portable purpose, good quality disinfectant with optimum concentration must be used. Also keeping in view, the significance as well as risks associated with treatment systems, it becomes necessary to minutely monitor the effluents especially if it has to be used in irrigation and urban reuse where it comes in direct contact with humans. For that, it is desirable to have technically sound as well as skilled manpower for the operation and maintenance of STP's.

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