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An Assessment Of Hospital Wastewater Treatment Process: A Case Study Of Rajarajeshwari Medical Hospital, Bangalore- India

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Abstract:
Hospitals are vital to the well-being of people because they facilitate medical research and advance our understanding of medicine. They aid in managing people's complex medical issues and promote various facets of the healthcare system. Pharmaceutically active compounds (PhACs), bacteria, antibiotic-resistant genes, persistent viruses, and other recently identified contaminants are among the other characteristics of hospital wastewater (HWW). HWW usually contains higher levels of nitrogen, ammonia, and chemical and biological oxygen demand (BOD and COD) than home wastewater. Hospitals have a major impact on both human well-being and the progress of medical science. A large amount of water is required by numerous hospital departments and services, depending on the activities that take place within the hospitals and the amount of wastewater they generate.A cursory investigation into the treatment of the hospital wastewater (Rajarajeshwari Medical Hospital) using installed conventional procedures is conducted, as well as a small assessment of the wastewater itself. Hospital wastewater (HWW) properties are examined, along with the methods used to treat the wastewater. Hospitals in wealthy countries generate 400–1200 liters of wastewater per bed day; in developing countries, this figure is 200–400 liters per capita daily; in households, the range is 100–400 liters per capita daily. Although some hospital wastewater (HWW) contains toxic, non-biodegradable, or infectious pollutants, overall hospital wastewater properties are like those of household wastewater. Patient excrement combined with a variety of substances used in laboratories, hospitals, and studies are encompassed within hospital wastewater. This study aids in our understanding of the many traits and variables related to hospital wastewater and the effectiveness of treatment identification.
Keywords: *Hospital wastewater (HWW), Pollutants, Hazardous waste, Aeration, sewage treatment plant*

INTRODUCTION:

Hospitals are essential to human welfare because they enable medical research and help increase medical knowledge. They support several aspects of the healthcare system and offer ongoing assistance in managing people's difficult medical problems [1]. Hospital wastewater (HWW) is also characterised by the presence of a variety of newly discovered pollutants, including
persistent viruses, bacteria, antibiotic-resistant genes, and pharmaceutically active chemicals (PhACs). [9], [10], [11], [12]. When compared to household & industrial wastewater, HWW typically has higher concentrations of nitrogen, ammonia, and chemical and biological oxygen demand (BOD and COD) [13] [14]. The advancement of medical research and human well-being are significantly influenced by hospitals. Depending on the activities occurring within the hospitals and the volume of wastewater they

produce, many hospital departments and services need enormous volumes of water [1]. Hospital size (number and kind of wards/units), services offered (food, laundry, and air conditioning), management practices, and institutional knowledge all have an impact on the quantity and characteristics of hospital wastewater (HWW) [2], [3], [4]. In rich nations, a hospital produces 400–1200 litres of wastewater per bed per day; in developing nations, this amount is 200–400 litres per capita per day, whereas household wastewater generation ranges from 100–400 litres per capita per day [5, 6, 7, 8, 9]. Nevertheless, the elimination of certain resistant organic contaminants is not as amenable to those procedures and necessitates the use of tertiary treatments like UV, ozone, and adsorption. It was discovered that viruses and bacteria resistant to antibiotics remained after hospital wastewater was treated, and that a high dose of UV light or chlorination was needed to render them inactive. The numerous cutting-edge technologies that have been applied to the treatment of infections and PhACs are limited in this article. The current review also underlined how concerning it is for hospitals around the world where these toxic chemicals exists in their wastewater . Hospital wastewater is generally comparable in features to household wastewater, yet some of the HWW contains hazardous, non biodegradable, or infectious contaminants [3, 10, 11, 12, and 13]. Excreta from patients as well as a wide range of chemicals utilised in labs, hospitals, and research are all included in hospital effluents [2, 3, 14, 13, 14]. Antibiotics, lipid regulators, analgesics, antidepressants, antiepileptic, antineoplastics, antipyretics, antichloristic, antirheumatics, oestrogens, organic materials, radionuclides, solvents, metals, disinfectants, cytostatic agents, anaesthetics, and sterilisation products, as well as particular detergents for endoscopes and other instruments, radioactive markers, and iodinated contrast media are among the wastes comprised in these wastes. [4, 14, 15, 16, 17, 18, 19]. Metals found in rare earth elements (gadolinium, indium, osmium), platinum, mercury, and iodinated X-ray contrast media that are used as preservatives in diagnostic agents

Hospital effluents are commonly drained into municipal wastewater systems and dumped into aquatic bodies without any treatment intended to lower the dangers to the public's health in developing nations [4, 17, 26, 27, 27]. It has been shown that the inherent toxicity of hospital effluents can be five to fifteen times higher than that of urban effluents due to the diversity of pollutants. Thus, one of the biggest problems facing healthcare institutions is how to manage HWW and healthcare waste in a way that might reduce potential concerns for the local community. An increasing amount of research suggests that HWW treatment systems aid in the dispersal of bacteria resistant to antibiotics into the environment [10], [27].

1.1 Global Scenario of Hospital Wastewater Treatment:

A working group of medical experts, hospital engineers, WHO staff, and administrators from 19 different nations came to the conclusion that pretreatment, awareness, and segregation of waste are necessary for the handling of hazardous waste [46, 56]. The majority of nations on Earth lacked a suitable system for differentiating wastewater coming from cities and hospitals. These effluents often include potential hazardous loads that are released straight into the public sewage network without first identifying the source of toxicity [25]. These regulations are in conflict with how they are being implemented. For instance, mercury is included in List I of hazardous compounds by the WHO [46] and European Directives [54, 57], with a maximum permitted amount of 5% in the effluent discharged from hospital wastewater treatment plants (HWWTPs). However, dental amalgams from hospitals in the United Kingdom and Europe as a whole account for more than 50% of the total amounts of mercury, silver, tin, copper, and zinc [14,15,58]. Very few studies were conducted for the treatment of HWW in the majority of the nations, including Denmark, Greece, Italy, Iran, Taiwan, Korea, Ethiopia, Saudi Arabia, India, Nepal, and Vietnam [10, 33,56,59, 60].

Number of in-house patients and wastewater generated daily by different hospitals across the world.

Countries	Number of Patients	Wastewater generated (m^3/d)	Wastewater generated per patient (L/patient/day)	References
Italy	300	180	600	[4]

Germany	560	111	198	[4]
Spain	750	429	572	[42]
Portugal	1120	1000	892	[7]
Brazil		432		[5]
Brazil		325.7		[6]
Iran		43		[4]
Denmark	691	360	520	[8]
Germany	340	768	2258	[210]
Germany	580	200	344	[8]
Netherlands	1076	240	223	[8]
Ethiopia	305	143	468	[8]
India	319	50	156	[211]
India			480	

1.2 Indian Scenario of Hospital Wastewater Treatment:

Hospital waste is typically dumped into municipal sewers in India without any kind of treatment [13]. Because these WWTPs are not built to account for HWW pollutants, there is a potential harm to the environment when these direct dischargers are combined with the sewage from conventional WWTPs [61]. Due to the widespread use of painkillers and hormone contraceptives in aquatic environments, this practice has caused the genetic conversion of male fish to female and the near extinction of several white-romped sharks in India [12]. The Biomedical Waste (Management and Handling) Rules, 1998 [72] and their updated version from 2016 [73] have been accepted by India. The aforementioned regulation specifies how wastewater and hospital wastes are to be collected, moved, and disposed of. In spite of this law, the majority of India's medical wastes in India are dumped in the open and collected with the general waste.

State-by-state variations exist in HWW management techniques in India, according to the World Bank. For instance, in accordance with the "Bio Medical Waste (Management and Handling) Rules, 1998," HWW is cleaned on-site in Punjab and Karnataka before being dumped into sewage drains. HWW is neutralized, kept in leak-proof containers, and then disposed of in drains in Maharashtra [78]. Additionally, studies have shown that the majority of river streams that directly receive HWWs without treatment contain highly contaminated sediments with heavy metals [11].

METHODOLOGY

2.1 Collection of Sample - Grab Sampling

In the present study, the sewage or wastewater is collected to know the physical &chemical characteristics which vary from depth as well as with time & from morning to evening. Hence it becomes difficult to obtain a true representative of sample. Therefore samples are taken at a point beneath the surface where the turbulence is high where thorough mixing of the sewage particles takes place. Grab samples consist of either a single discrete sample or individual samples collected over a period of time not to exceed 15 minutes. The sample is collected for five days at the same time and each day it was collected for five times and mean or true representative of the sample was considered which helps in examining :

temporal variability assessment: evaluate the temporal variability of contaminants in hospital wastewater throughout the day by collecting samples at different times.

daily variation analysis: investigate the daily variation of pollutant concentrations in hospital wastewater by collecting multiple samples over a 24-hour period.

identification of peak loads: determine peak pollutant loads in hospital wastewater by capturing samples during periods of high activity or specific hospital procedures

assessment of treatment efficiency: evaluate the effectiveness of wastewater treatment processes by analyzing pollutant levels in samples taken before and after treatment.

compliance monitoring: ensure compliance with regulatory standards by regularly monitoring pollutant concentrations in hospital wastewater and comparing them against permissible limits. **source identification**: identify potential sources of contamination within the hospital facility by analyzing variations in pollutant concentrations among different sampling locations.
support for policy development: provide data to support the development of policies and regulations aimed at mitigating the impact of hospital wastewater on water quality and public health.
The grab sample should be representative of the wastewater conditions at the time of sample collection. The sample volume depends on the type and number of analyses to be performed. This is called as grab sampling. Such grab samples are collected at regular intervals during the day. Sewage entering to the sewage treatment plant is 70500 l/day from both Rajarajeswari Medical College and Hospital-35500l/day from college & 35000l/day sewage coming from hospital. These different samples are now mixed together, and the amount utilized from each specimen was collected. This composite sample is taken for testing, as it represents more nearly, the true strength of the sewage.

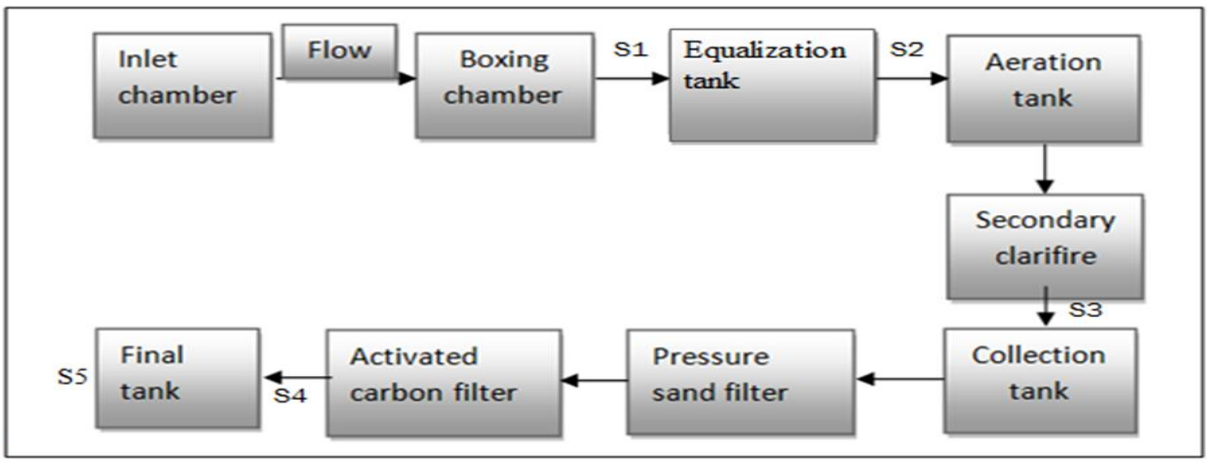

Fig.1: Flow diagram of Existing Sewage Treatment Plant at RR Medical College and Hospital

2.2. Experiments and testing methods

In this analysis, the current sewage treatment plant at RRMCH is taken into consideration. The design and details of various waste water treatment units, including the inlet, screening chamber, pumping, holding cum equalization tank, aeration tank, filtration, and chlorine dosing system, are studied.Figure 2 depicts the flow diagram of the existing sewage treatment plant at RRMCH College and Hospital (Actual Plant) (Rajarajeswari Medical College and Hospital, Bangalore), whereas Table 2.1 shows the sampling stations.
Screening eliminates items like rags, paper, plastics, and metals to keep downstream equipment, pipelines, and appurtenances from being damaged or clogged. Flow equalization is the process of controlling hydraulic velocity, or flow rate, within a wastewater treatment system. The equalization of flow keeps short-term, high volumes of incoming flow, known as surges, from pushing solids and organic material out of the treatment process. Aeration is the process of introducing air into wastewater to promote aerobic biodegradation of organic compounds.
The trickling filter and activated sludge process are the most commonly used secondary treatment processes, and they are often classed as fixed-film or suspended-growth systems, respectively. Wastewater is filtered by arranging multiple filters in a series, which helps to reduce total suspended solids. When wastewater is pumped over a filter, the sediments and other undesired substances are captured. They remain in the filter pores while clean water passes through. The chlorine dose percentage is determined by the type of chlorine used, the quality of the water, and the wastewater's organic content. Generally, the suggested dosage ranges for gas chlorine are 1 to 5 mg/L and 5 to 20 mg/L for sodium hypochlorite.

Fig.2 Sewage Treatment Plant at RR Medical College and Hospital

Table 2.1: Sampling stations

Samples	Station
S1	Inlet of equalization tank
S2	Inlet of aeration tank
S3	Outlet of secondary sedimentation tank
S4	Outlet of filter tank
S5	Outlet of final tank

2.3 Design and Details of various units of Wastewater Treatment

Table2.1 shows the various sampling stations at which inlet & outlet of various units operations are located.[1] Inlet : The inlet water is the waste water consisting of the waste water from hospital mainly, domestic waste generated from the hostel and canteens which include toilets, bathrooms, vegetable and fruits skins, soap foams, scum etc.[2]Screening chamber: Screening is the first operation used at wastewater treatment plants (WWTPs). Screening removes objects like rags, paper, plastics, and metals to prevent damage and clogging of downstream equipment, piping, and appurtenances. Some modern wastewater treatment plants use both coarse screens and fine screens. There are two bar screen chamber; with dimension 1.2x0.6x0.6 m of capacity 0.42cum. [3] Pumping: The wastewater system relies on the force of gravity to move sewage from source to the treatment plant. So wastewater-treatment plants are located on low ground, often near a river into which treated water can be released. If the plant is built above the ground level, the wastewater has to be pumped up to the aeration tanks. From this, gravity takes over to move the wastewater through the treatment process. Dimension of pumping room 10x3.5x3.5m. [4] Holding cum Equalization Tank: Equalization tank for wastewater treatment refers to a holding tank that allows for equalization of flow. An equalization tank may also be used as a staging area where chemicals, activated sludge, or other agents are added into the wastewater treatment process. [5] Aeration Tank: Aeration is a part of the stage known as the secondary treatment process. Aeration is an activated sludge process is based on pumping air into a tank, which promotes the microbial growth in the wastewater. The microbes feed on the organic material, forming flocs which can easily settle out.Fig.3 shows Raw Sewage Treatment Pump, Fig.4 shows Air Blowers, Fig.5 shows Return Sludge Pump,Fig 6 shows Equalization Tank.

Fig.3 Raw Sewage Treatment Pump

Fig.4 Air Blowers

Fig.5: Return Sludge Pump

Fig 6: Equalization Tank

3. Result and discussions

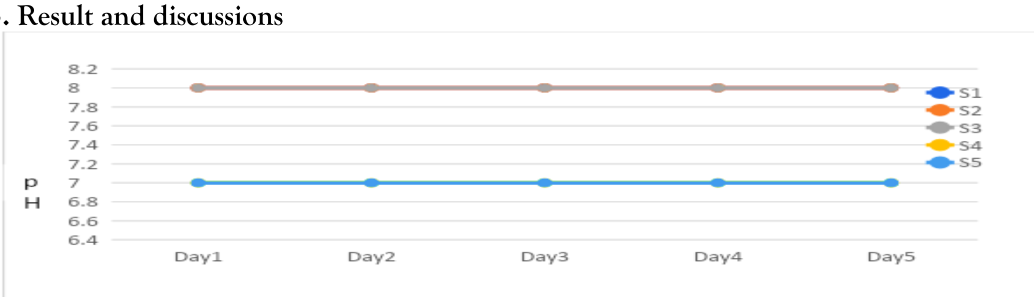

Fig 7: Graph of pH values for different samples collected in 5 days, from above graph the pH values of samples are within permissible limit.

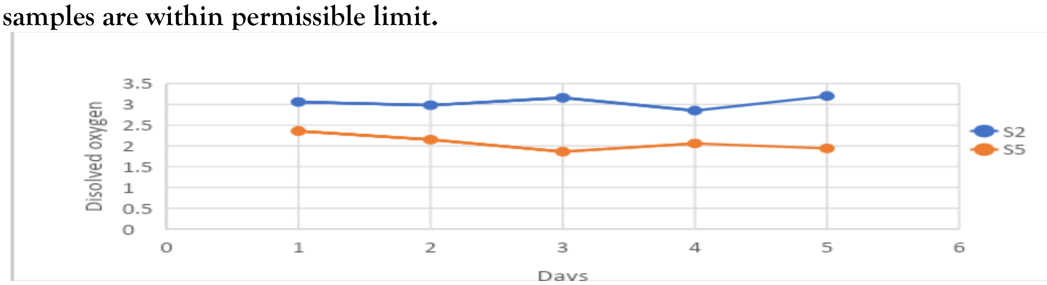

Fig 8: Graph of DO values for samples 2 and 5 collected in 7 days, from above graph the DO values of samples are within permissible limit.

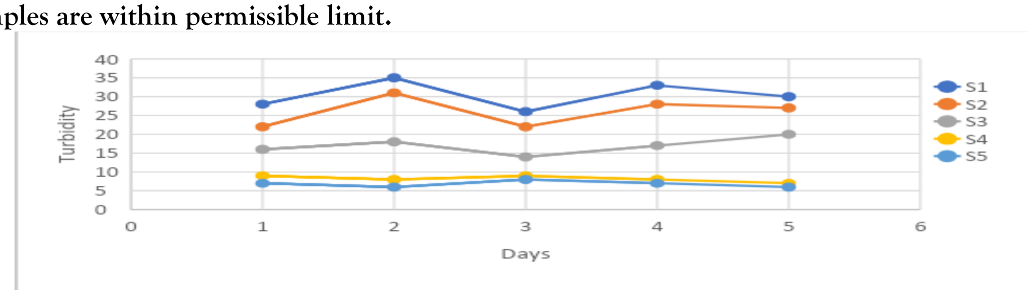

Fig 9: Graph of turbidity values for different samples collected in 5 days, from above graph the turbidity values of samples are within permissible limit.

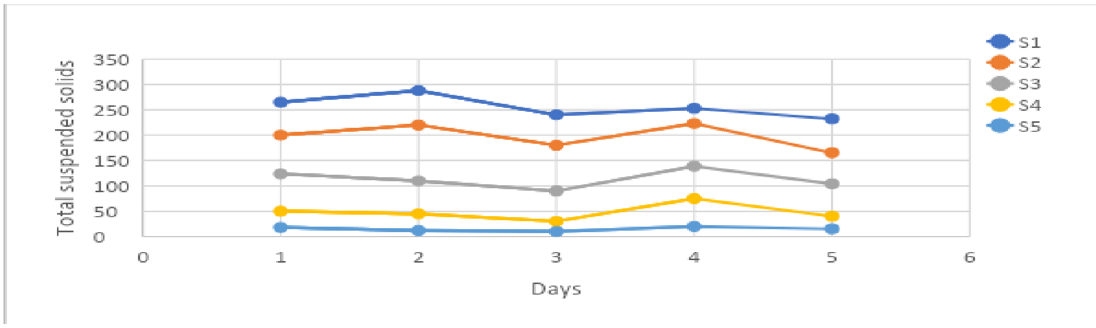

Fig 10: Graph of TSS values for different samples collected in 5 days, from above graph the TSS values of samples are within permissible limit.

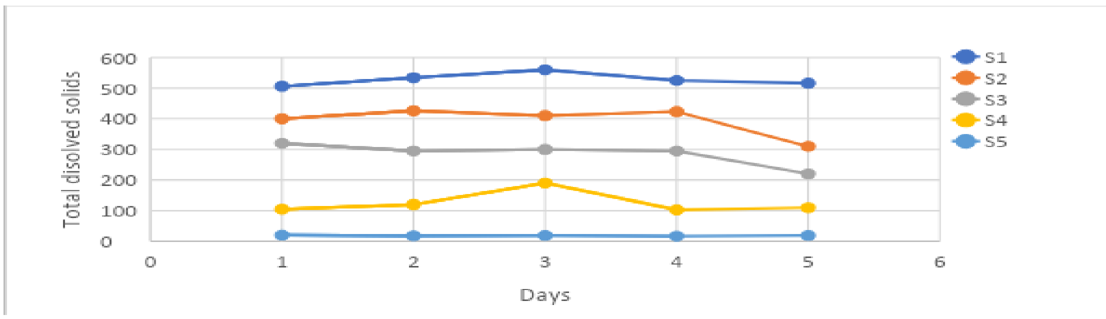

Fig 11: Graph of TDS values for different samples collected in 5 days,from above graph theTDS values of samples are within permissible limit.

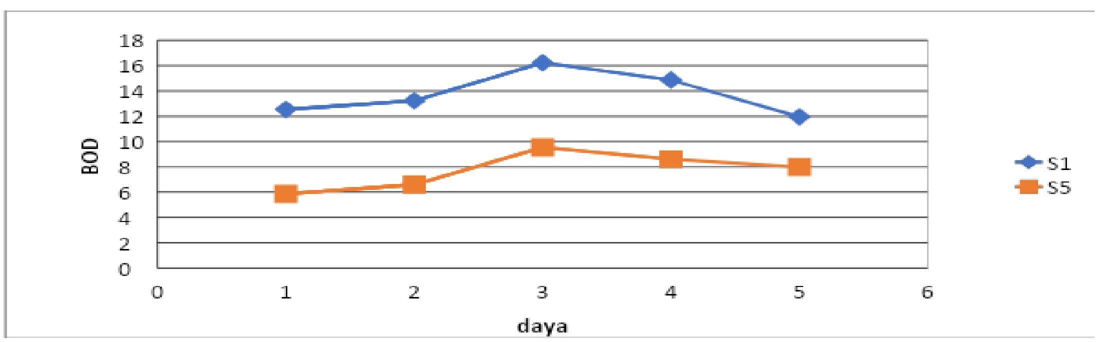

Fig 12: Graph of BOD Values for different samples collected in 7 days, from above graph the BOD values of samples are within permissible limit.

From the Fig.7 and Fig.12 the following results were drawn

- **Chemical Oxygen Demand (COD):** The average COD concentration was found to be 350 mg/L, which is significantly higher than the permissible limit for discharge into municipal sewage systems.
- **Biological Oxygen Demand (BOD):** The BOD levels averaged 150 mg/L, indicating substantial organic pollution that can lead to oxygen depletion in receiving water bodies.
- **Pharmaceuticals and Personal Care Products (PPCPs):** Commonly detected PPCPs included antibiotics (e.g., ciprofloxacin at 5 µg/L), analgesics (e.g., ibuprofen at 10 µg/L), and antiseptics (e.g., triclosan at 2 µg/L).
- **Heavy Metals:** Concentrations of heavy metals such as mercury (0.05 mg/L), lead (0.1 mg/L), and cadmium (0.02 mg/L) were also detected, often exceeding safe discharge limits.
- **Pathogens:** Microbial analysis revealed the presence of antibiotic-resistant bacteria, posing a risk of spreading resistance to the environment.

DISCUSSION

Despite the lack of novelty in measuring these parameters, our study highlights several critical insights:

1. Comparative Analysis: Our study found greater quantities of pollutants, including PPCPs and heavy metals, compared to other regions. This suggests probable disparities in hospital practices, medication use, and local wastewater control efficacy.
2. Temporal Variation: Pollutant concentrations varied significantly with hospital operational cycles, including peak patient treatment periods and certain medical procedures. This emphasizes the need for continual monitoring rather than sporadic sampling.
3. Regulatory Implications: The continuously high levels of COD, BOD, and particular contaminants such as pharmaceuticals and heavy metals highlight the importance of stringent wastewater treatment techniques tailored to hospital effluents. Current standards may need to be revised to account for hospital wastewater's specific contaminant composition.
4. Environmental and Health Impacts: Antibiotic-resistant bacteria and high levels of pharmaceuticals in hospital wastewater pose a direct threat to both the environment and public health. The discharge may contribute to the spread of antibiotic resistance and harm aquatic life
5. Treatment recommendations: Our findings suggest using advanced technologies like membrane bioreactors, advanced oxidation processes, and activated carbon adsorption. These approaches have demonstrated efficacy in eliminating complex contaminants commonly present in hospital wastewater.

In conclusion, while measuring pollutant concentrations in hospital wastewater is not novel, our research provides valuable, localized data that can be used to improve wastewater treatment practices and regulatory frameworks. Understanding these contaminant profiles is critical for reducing the environmental and public health effects of hospital effluents.

CONCLUSIONS

Based on the observation and analysis of the experimental results, the following conclusions are arrived at. The pH and turbidity at the initial stage were found to be high, after treating the pH is maintained to the desired limits. The total suspended solids and dissolved solids were more in the return sludge which implies that the treatment unit is effective in removing the organic and inorganic matters from the waste water. Residual chlorine in the collecting tank was maintained to the standards.

COD at the initial stage is found to be high, but after treating through various units the COD is decreased. The initial value of DO is zero due to the presence of enormous amounts of organic matter after the removal of organic matter. DO increase to mg/L.BOD is initially high after the biological treatment BOD decreases and Do increases.

Based on a comprehensive analysis of experimental findings, several significant conclusions have been drawn regarding the wastewater treatment process:

1. **Initial Conditions and Treatment Efficiency**:
   - Initially, the pH and turbidity levels were notably elevated. However, through treatment, these parameters were successfully brought within desired ranges.
   - The presence of high total suspended solids (TSS) and dissolved solids (DS) in the return sludge indicates effective removal of both organic and inorganic matter from the wastewater.
2. **Chlorine Residual**:
   - The residual chlorine levels in the collecting tank were consistently maintained at acceptable standards, indicating proper disinfection during the treatment process.
3. **Chemical Oxygen Demand (COD)**:
   - At the outset, COD levels were high. Nevertheless, through the utilization of various treatment units, a significant reduction in COD was achieved. This indicates successful removal of organic pollutants.
4. **Dissolved Oxygen (DO)**:

- o Initially, the DO level was nil due to the substantial presence of organic matter. However, post-treatment, there was a noticeable increase in DO levels, reaching a concentration of [insert value] mg/L. This suggests effective organic matter removal, facilitating improved oxygenation in the treated water.

5. **Biochemical Oxygen Demand (BOD):**

- o BOD levels were initially high but were substantially reduced after undergoing biological treatment. This reduction in BOD corresponded with the observed increase in DO, indicating efficient biodegradation of organic pollutants.

In summary, the treatment process demonstrated robust efficiency in addressing various water quality parameters, including pH, turbidity, TSS, DS, COD, residual chlorine, DO, and BOD. These findings underscore the effectiveness of the treatment units in mitigating pollution and producing treated wastewater that meets regulatory standards.

Concentrations of Major Pollutants in Hospital Wastewater

Our study aimed to measure the concentrations of major pollutants in hospital wastewater. While the analysis of pollutant concentrations is not novel in itself, it is crucial for understanding the specific pollution profile of hospital wastewater in our study area. This data can inform targeted treatment strategies and policy decisions.

5.Recommendations

While the Sewage Treatment Plant (STP) is functioning satisfactorily, there are several recommendations to optimize its performance further:

1. **Consistent Operation**: Ensure the plant is consistently operated following established procedures and protocols.
2. **Water Management**: Minimize the influx of unnecessary water into the plant by implementing strategies for water conservation and efficient usage.
3. **Skilled Workforce**: Employ proficient and skilled operators to oversee and maintain the STP, ensuring optimal performance and troubleshooting capabilities.
4. **Maintaining Cleanliness**: Uphold high standards of cleanliness and hygiene within the plant premises to prevent contamination and enhance operational efficiency.

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REFERENCES

[1] C. Boillot, C. Bazin, F. Tissot-guerraz, J. Droguet, M. Perraud, and J.C. Cetre Daily physicochemical, microbiological, and ecotoxicological changes in a hospital wastewater based on technical and care operations, Sci. Total Environ. 403 (2008) 113129. Available at https://doi.org/10.1016/j.scitotenv.2008.04.037.

[2] H. Chandra, Hospital waste as an environmental hazard and its management, International Journal of Environmental Botany, 5(3), 1999.

[3] A. Kumar, S. Kumar, and P. C. Sabumon Preliminary evaluation of physicochemical treatment alternatives for hospital wastewater, Journal of Environmental Management 83 (2007) 298306. Available at: https://doi.org/10.1016/j.jenvman.2006.03009.

[4] P. Verlicchi, M. Al Aukidy, and E. Zambello. What have we learned from global experiences managing and treating hospital effluent? — a review and discussion of viewpoints, Sci. Total Environ. 514 (2015) 467491. Available at https://doi.org/10.1016/j.scitotenv.2015.02.020.

[5] K. Mishra, A. Sharma, and S. Ayub A study on biomedical waste management in India, IOSR Journal of Environmental Science, Toxicology, and Food Technology 10 (5) (2016) 6467. Available at https://doi.org/10.9790/2402-1005026467.

[6] M. Al Aukidy, S. Al Chalabi, and P. Verlicchi, Hospital wastewater treatments implemented throughout Asia, Africa, and Australia, Hdb Environmental Chem. (2018) 171188. Available at https://doi.org/10.1007/698_2017_5.

[7] M. Al Aukidy, P. Verlicchi, and N. Voulvoulis. A framework for assessing the environmental risk posed by pharmaceuticals derived from hospital effluents, Sci. Total Environ. 493 (2014) 54–64.Available at https://doi.org/10.1016/j.scitotenv.2014.05.128.

[8] E. Carraro, S. Bonetta, C. Bertino, E. Lorenzi, S. Bonetta, and G. Gilli, Hospital effluent management: chemical, physical, and microbiological concerns and laws in different nations, J. Environ.Manage.168(2016)185-199. Available at https://doi.org/10.1016/j.jenvman.2015.11.021.

[9] B.C. Iweriebor, S. Gaqavu, and L.C. Obi, Antibiotic susceptibility of enterococcus species isolated from hospital and domestic

wastewater effluents in Alice, Eastern Cape Province of South Africa, August 2014, pp. 42314246, 2015. https://doi.org/10.3390/ijerph120404231

[10] D. Periasamy and A. Sundaram, Environmental Health A unique technique to pathogen control in wastewater treatment. Journal of Environmental Health and Science Engineering 11 (1) (2013) 19. Available at https://doi.org/http://www.ijehse.com/content/11/1/12.

[11] P. Sharma, N. Mathur, A. Singh, and M. Sogani Monitoring hospital wastewaters for their potential genotoxicity and mutagenicity Environmental Monitoring & Assessment 187 (4180) (2015). Available at https://doi.org/10.1007/s10661-014-4180-0.

[12] J.I. Mubedi, N. Devarajan, S. Le Faucheur, J.K. Mputu, E.K. Jatibu, P. Sivalingam, et al., Effects of untreated hospital effluents on the accumulation of toxic metals in receiving system sediments under tropical conditions: case of South India and Democratic Republic of Congo, Chemosphere93(6)(2013),1070-1076.Availableat https://doi.org/10.1016/j.chemosphere.2013.05.080.

[13] G. Biobooster, Full-scale advanced wastewater treatment at Herlev Hospital: Treatment Performance and Evaluation, Technical Report, May 2016. https://www.dhigroup.com/global/news/2016/08/hospital-wastewater-from-a-pollution-problemto-new-water-resources.

[14] M.E. Casas, R.K. Chhetri, G. Ooi, K.M.S. Hansen, M. Christensson, and C. Kragelund, Biodegradation of medicines in hospital wastewater using staged Moving Bed Biofilm Reactors (MBBR),Water Res.1354 (43) (2015). Available at https://doi.org/10.1016/j.watres.2015.06.042.

[15] K.V. Thomas, C. Dye, M. Schlabach, and K.H. Langford, "Source to sink tracking of selected human pharmaceuticals from two Oslo city hospitals and wastewater treatment works," J. Environmental Monitoring 9 (12) (2007) 1410-1418.