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A Descriptive Study on Performance Evaluation of Sewage Treatment System

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Abstract: As The rapid expansion of modern housing and industrialization around the cities has polluted environment. This trend was observed in many developed countries in the beginning of nineteenth century which resulted in the contamination of air, water, soil etc. with pollutants. If the pollutants are released in the environment and left untreated they would cause serious diseases in both humans and animals. Large scale pollution of water bodies around the globe became a major problem due to release of industrial and domestic waste directly in water streams. To prevent the leaching of pollutants in the ground water scientist developed various methods of wastewater treatment based on the hazardous chemicals and microorganisms, which were present in the untreated water. Modern sewage treatment plants were installed in big cities to treat the water released from households. Most STPs were designed based on the stringent criteria to check the pollutants levels in the treated water so that when it is released or recycled it is safe to the environment. Modern day STP plants have a high cost of operation due to huge power consumption. In order to reduce the pollutant levels in the wastewater this study was conducted using a Eco Bio Block (EBB) techniques with aeration and without aeration. A comparison of EBB was also carried out with MBBR technique. Our results show that when EBB technique was applied with aeration it is effective in reducing pollutant levels in the wastewater akin to MBBR. In addition, we tested the EBB without aeration and found that the treated waste water has relatively low levels of BOD, COD and turbidity, suggesting that the treated water can be utilized for landscaping and horticulture activities. Overall, the outcomes from this study are encouraging to adopt EBB in smaller towns and in small housing societies to treat the wastewater prior to release. The paper focuses on reviewing the various sewage treatment methods and their results.
Keywords: STP, Wastewater Treatment, Removal Efficiency, BOD, COD.

I. INTRODUCTION

In early days' waste products of the society including human excreta were been collected, carried &disposed of manually by the human beings and this system is called dry conservancy system. This system leads to bad smell and health hazard. Now a day with the march of civilization & development proper disposal of waste done by a new system called sewerage system that had replaced the old dry conservancy system. In the sewerage system, the waste mixed with water is called sewage. Sewage carried through close pipes or lines called sewers to the place away from the residential area under the force of gravity to Sewerage Treatment Plant (STP). Here sewage treated before disposing in environment. Sewage includes dissolved and suspended organic solids, number of living microorganism, which lead into bad condition, odour and appearance. Microorganism may contain disease-producing (pathogenic) bacteria and viruses that can be readily transferred by sewage from sick individuals to well ones. So by removing it properly environment can be maintained in an acceptable and safe condition.

Water is the most significant resource in the world, and now is in danger due to urbanization, increasing population, inadequate rainfall, climatic change, and economic development etc. Water is required to be used efficiently due to its increasing demand [1]. This can be achieved by using existing sources of water with proper management and adopting both traditional and modern approach for improving efficiency such as ground water recharge, conservation of water, and reuse of waste water etc. Among all the methods, reuse of waste water has become the most important for both economic and environment reasons. Earlier wastewater after treatment was used in agricultural activities but nowadays it is intensifying its applications in urban, industrial and construction industry. The important pathways for reuse of waste water contains surface water replenishment, irrigation, ground water recharge, and industrial use [2]. The volume of water carried through each pathway depends on degree of water utilized for different purpose, climatic factors, watershed characteristics, quantity of direct and indirect water reuse. Also water problems are in need of immediate assistance because of increasing environmental hazards to human health.

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A. Sewage Treatment Plant (STP)

Sewage is the waste produced from institutional, industrial, residential, and commercial establishments. Sewage treatment involves number of stages for eliminating the contaminants from household or industrial sewage water [3]. Sewage treatment plant treats the waste water/sewage before its disposal into the water body so that it can be used in domestic or agricultural activities safely. Sewage consists of high quantity of inorganic and organic wastes. It becomes very important to treat sewage appropriately before letting into any source of water.

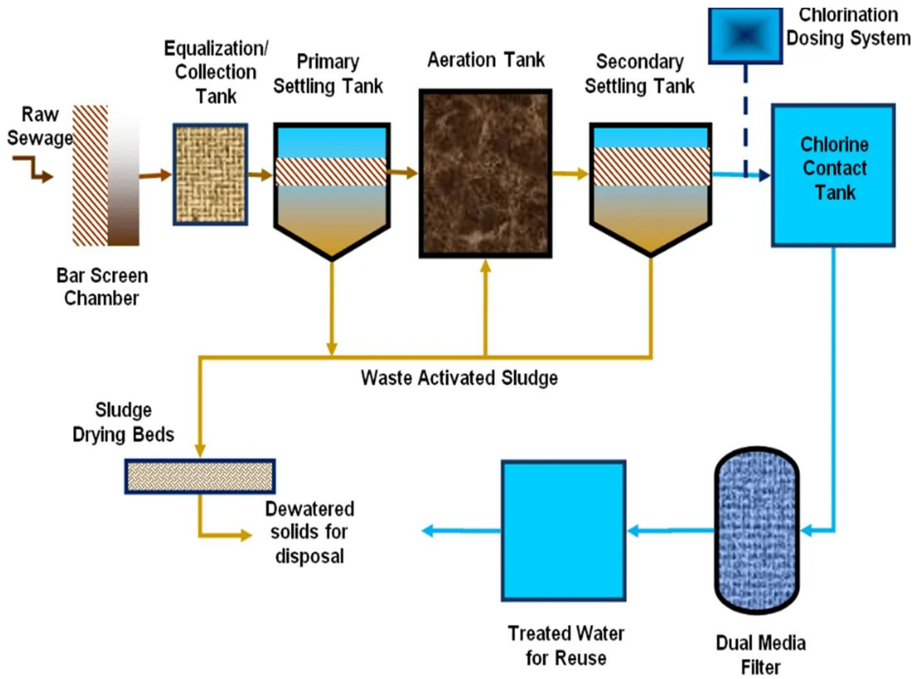

Fig. 1: Typical stages in the Conventional Treatment of Sewage

1) Preliminary Treatment: This is the initial stage/ first stage of wastewater treatment which includes removal of large materials or coarse solids usually found in raw water. This treatment consists of filtering screen which helps in breaking the large objects to prevent blockage in treatment process.
2) Primary Treatment: This treatment takes place after preliminary treatment which aims to reduce any kind of heavy solids that are settled at the bottom due to sedimentation while light solids like oil and grease float over the surface by skimming [3]. After removing the both floating and settled materials the remaining liquid is discharged to next stage of treatment. The efficiency of primary treatment is to remove around 60% of suspended solids from sewage.
3) Secondary Treatment: This treatment involves a separation process for removal of microorganisms from treated water before moving to next stage of treatment. The efficiency of secondary treatment is to remove around 90% of suspended solids from sewage.
4) Tertiary/Advanced Treatment: This treatment aims at removing those sewage constituents which were not removed in prior stages. Sometimes treated sewage is disinfected physically or chemically before its discharge into the ecosystem (river, sea, wet lands, lake, ground, etc. [5,6]

B. Problem Statement

1) The efficiency and sustainability of sewage treatment plants (STPs) are critical for maintaining public health and protecting environmental resources.
2) However, the performance of different types of STPs can vary significantly based on the technology used, operational practices, and local environmental conditions.
3) There is a need for a comprehensive evaluation and comparison of various sewage treatment processes to identify the most effective and sustainable solutions for diverse settings.

C. Objectives Of The Present Study

The specific objectives of the present study areas below.

1) To analyze the physio-chemical parameters of influent and effluent like, Turbidity, pH, Chemical oxygen demand, Temperature, Total Suspended Solids, Total Dissolved Solids, chlorides, Nitrates.
2) To analyze the biological parameters of influent and effluent like, Biological oxygen demand (BOD).
3) To determine the overall performance STP in terms of removal/reduction efficiency.

II. LITERATURE REVIEW

Nidal Mahmoud et al (2004) studied the treatment of sewage at 15°C was investigated in a one-stage up flow anaerobic sludge blanket (UASB) reactor and a UASB-Digester system. The latter consists of a UASB reactor complemented with a digester for mutual sewage treatment and sludge stabilization. The UASB reactor was operated at a hydraulic retention time of 6h and a controlled temperature of 15°C, the average sewage temperature during wintertime of some Middle East countries.

Amit Sonune and Rupali Ghate (2004) studied that Wastewaters are waterborne solids and liquids discharged into sewers that represent the wastes of community life. Wastewater includes dissolved and suspended organic solids, which are "putrescible" or biologically decomposable. Two general categories of wastewaters, not entirely separable, are recognized: domestic and industrial. Wastewater treatment is a process in which the solids in wastewater are partially removed and partially changed by decomposition from highly complex, putrescible, organic solids to mineral or relatively stable organic solids. Primary and secondary treatment removes the majority of BOD and suspended solids found in wastewaters. This paper covers all advanced methods of wastewater treatments and reuse.

Sheng et al.(2006), South Korea conducted the study In order to treat pesticide wastewater having high chemical oxygen demand (COD) value and poor biodegradability, Fenton-coagulation process was first used to reduce COD and improve biodegradability and then was followed by biological treatment. Optimal experimental conditions for the Fenton process were determined to be Fe2+ concentration of 40 mol/L and H2O2 dose of 97 mol/L at initial pH 3. The interaction mechanism of organophosphorus pesticide and hydroxyl radicals was suggested to be the breakage of the P S double bond and formation of sulfate ions and various organic intermediates, followed by formation of phosphate and consequent oxidation of intermediates.

Hong and Chiing (2009) performed a study on design of MBR type waste water treatment plant, which records 1.24×107 microbial count at receiving point and no value got detected at outlet.

Rakmi Abd.Rahman et.al (2010) studied that Biofilm reactors are increasingly used to treat industrial effluents with difficult components, this type of process has been applied to wastewaters containing various types of pollutants, such as those containing chlorinated organics. These have not been effectively removed by conventional activated sludge types of processes due to their recalcitrance. Biofilm reactors have biomass active even at very low concentrations of the target organics, rendering the reactor more efficient for removing trace toxic compounds in wastewaters.

Durga et al. (2013) performed the study on treatment efficiency of algae based waste water treatment plant which stated COD of 455.7 mg/l at receiving point and 206 mg/l at outlet.

Agayemang et al. (2013) write a research on water quality assessment of sewage treatment plant which stated pH of 10.6-11.4 at receiving point and 7.7-8.7 at outlet. The pH decreased because of sulphuric acid used in the treatment process.

Sahu and Negi (2015) conducted a study on performance evaluation of waste water treatment plant which recorded pH of 7.5 at receiving point and 7.1 at outlet.

Ashok et al. (2018) Conducted a study on sewage water management system was conducted by for design of decentralized waste water treatment which stated pH of 6.5-8.5 at receiving point and 6.5-8.5 at outlet.

III. METHODOLOGY

Data collection is a critical step in evaluating the performance of sewage treatment systems. This involves gathering both quantitative and qualitative data from various sources, including treatment plants, scientific literature, and regulatory reports. The following steps outline the data collection process:

Identification of Sewage plant and Collection of wastewater samples at various stages of the treatment process (influent, primary effluent, secondary effluent, tertiary effluent) and perform laboratory analyses to measure key parameters such as Turbidity, pH, Biological oxygen demand, and Chemical oxygen demand, Temperature, Total Suspended Solids, Total Dissolved Solids, Chlorides, Nitrites.

IV. MATERIALS

Sodium hydroxide, Ammonium buffer pH = 10, phosphate buffer, Magnesium sulphate solution, Calcium chloride and ferric chloride solution, distilled water, Sulfuric acid was used for the entire analysis.

V. PROCESS ADOPTED

1) pH

Was measured using the pH meter. Standardize the pH meter by immersing the electrode in a buffer solution of known pH, normally 4 and 9. Read the pH and calibrate, till it indicates the correct value for pH of buffer solution Ammonium buffer pH = 10. Rinse the electrode in distilled water and immerse them in sample. Read the pH value. pH Adjusted by using Common regulator caustic soda (sodium hydroxide).

2) Biological Oxygen Demand (BOD)

Is the dissolved oxygen amount, which is used by the heterotrophic microbes. We used OxiToP method for BOD estimation of Winkler's Titration. This method works on the principle that a decrease in the oxygen levels in a reactor causes a definitive pressure difference that can be measured with a pressure sensor and translated into mg/L of BOD. We took the 250ml sample bottles fitted with the instrument and added two drops of nitrification inhibitor. Two pellets of NaOH was added prior to putting the cap back on the OxiTop instrument and it was set to zero.

3) Chemical Oxygen Demand:

Analysis of organic matter in a wastewater sample is important to check the quality of water. The Chemical Oxygen demand (COD) is the amount of oxygen consumed during the oxidation of all organic matter by a chemical agent in a strong acid medium. The COD analysis is an easy, quick and inexpensive method to determine the amount of total organics in a wastewater/water sample. It is based on the amount of oxygen consumed by the oxidation of total organic matter using the Closed Reflux Colorimetric Method (5220 D in APHA). To measure the COD, sonicate the sample, add 3.5 ml H2SO4 and 1.5 ml digestion solution. Transfer the 2.5 ml solution into a glass ampule. Ampules were put into COD digester for 2 hours at 150oC. OD was checked at 600nm to determine the COD. COD concentration was determined after drawing the calibration curve.

4) Turbidity

Turbidity is the measurement of clarity or cloudiness of water sample. Suspended solids and dissolved coloured material lead to an increase in turbidity. It was measured by a turbidity meter

5) Temperature (Temp)

Digital Thermometer was used for analysis of temperature

6) Total Suspended Solids (TSS)

By Membrane Filtration Method. Take 50 mLof sample in Gooch crucible. Place the Gooch crucible on the glass fiber apparatus. Switch on the electrical supply. Liquid passes in the glass fiber.Solids remains on the Asbestos layer. Weigh the empty Gooch crucible before the experiment and after drying the crucible at about 103^{0c} in a oven to 15 mins.

7) Total Dissolved Solids (TDS)

By Gravimetrically after drying in an oven.

8) Chloride (Cl-)

By Argentometric Titration using Potassium chromate indicator. Titrate with standard N/35.5 AgNO3 solution till the colour changes from yellow to brick red. Note the amount of titrant used.

9) Nitrate – nitrogen (NO3 –N)

By Acid Treatment followed by Spectrophotometry. Treatment of sample: 1 mL HCl is added to 50 Ml clear/filtered sample, mixed. Calibration standards are prepared in the range of 0-7 mgNO3- -N/L, by diluting to 50 mL,1 mL of HCl is added and mixed.

Absorbance or transmittance is read againstre-distilled water set at zero absorbance or 100 % transmittance. A wavelength of220 nm is used to obtain NO3- reading and a wavelength of 275nm to determine interference due to dissolved organic matter.

VI. EXPERIMENTAL RESULTS

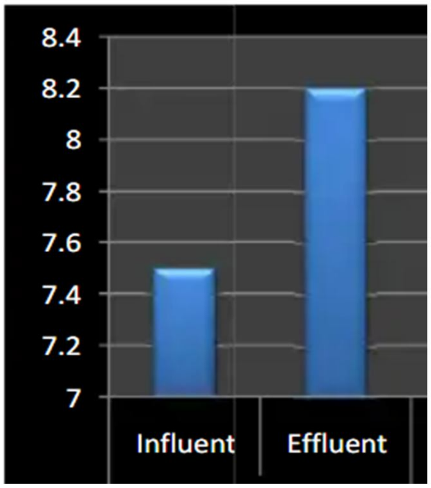

Fig. 2: Graphical Representation of pH

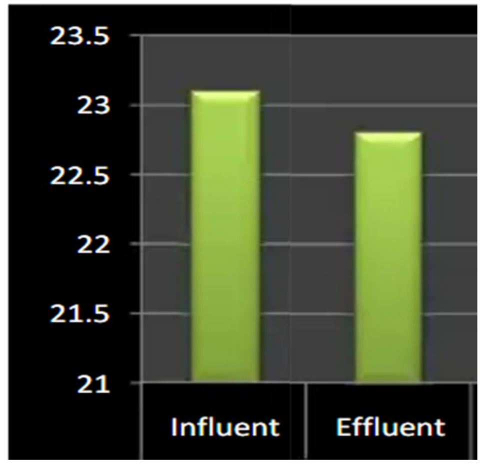

Fig. 3: Graphical Representation of Temp

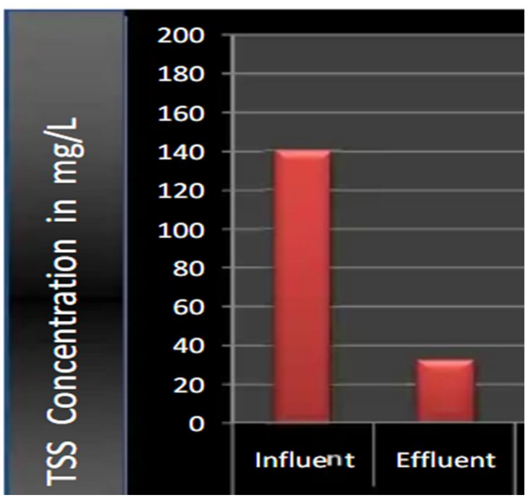

Fig. 4: Graphical Representation of TSS

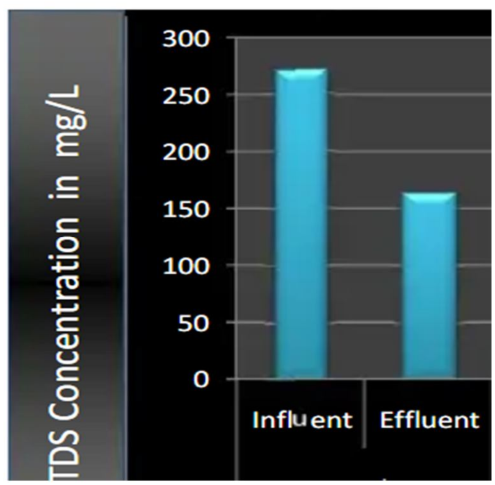

Fig. 5: Graphical Representation of TDS

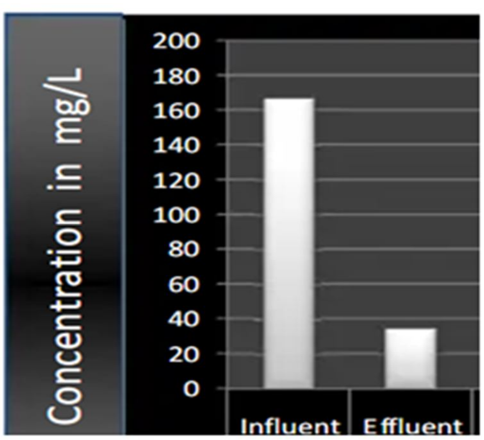

Fig. 6: Graphical Representation of BOD

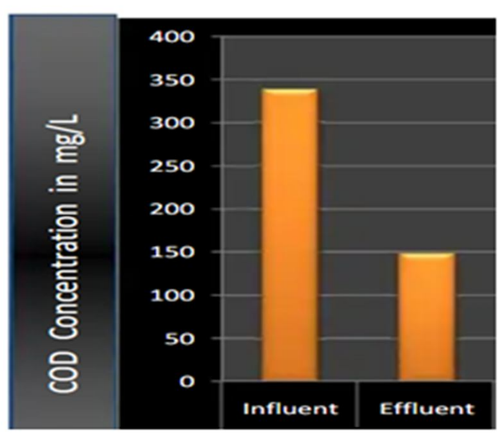

Fig. 7: Graphical Representation of COD

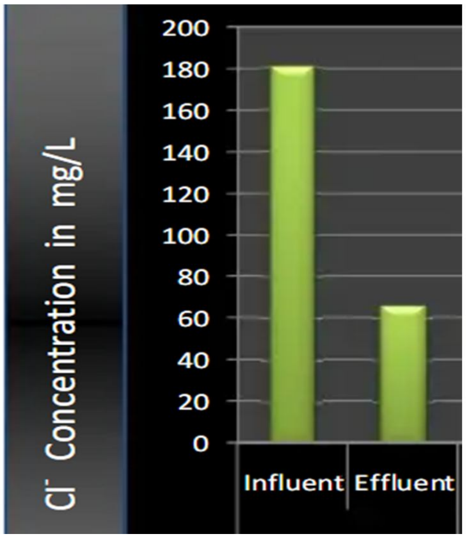

Fig. 8: Graphical Representation of Cl-

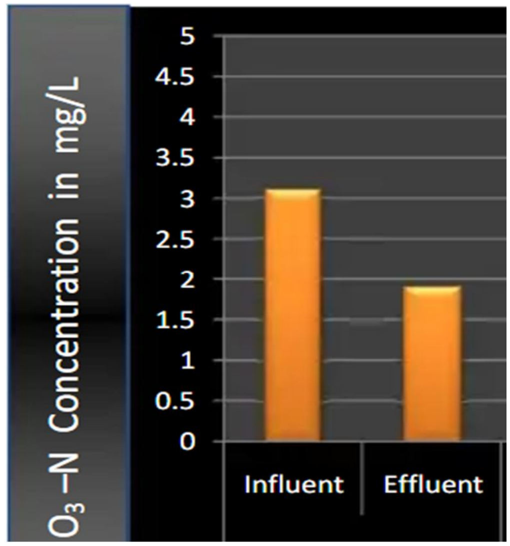

Fig. 9: Graphical Representation of N03-

Table 1: Test result of all Parameter

PARAMETER	Inlet (1)	Outlet (1)	Inlet (2)	Outlet (2)	Inlet (3)	Outlet (3)	AVG.
Ph	7.9	8.6	7.8	8.1	8	7.8	8
BOD	154	34	131	32	125	39	38.3
COD	148	83	139	76	141	80	67.6
Turbidimetry (NTU)	235	6	207	9	195	12	97
Temperature	18.4	18.1	17.3	17.8	18.2	17.6	17.3
Chloride	192	88	165	91	145	87	139.3
Nitrate	1.7	1.4	1.5	1.6	1.8	1.4	1.6
TSS	159	38	130	33	125	40	33.6
TDS	283	160	201	150	208	141	125.6

Table 1: A comparison of results

PARAMETER	CONCLUSION
pH	Lower than permissible limit
BOD	Higher than permissible limit
COD	Lower than permissible limit
Turbidity	Lower than permissible limit
Temperature	Lower than permissible limit
Chloride	Lower than permissible limit
Nitrate	Lower than permissible limit
TSS	Lower than permissible limit
TDS	Lower than permissible limit

VII. CONCLUSIONS

1) *PH* directly affects the performance of a secondary treatment process because the existence of most biological life is dependent upon the narrow and critical range of pH. In addition to all above, Chemical processes used to coagulate wastewater, dewater sludge or oxidize certain substances, such as cyanide ion requires that the pH be controlled within a narrow range. Thus, any variation beyond acceptable range could be fatal to a particular organism. Average Effluent value of pH recorded for this STP was also under permissible limit according to CPCB Effluent Discharge Standards into Land for Irrigation.
2) *Temperature* has an effect on the biological activity of bacteria present in sewage, and also it affects the solubility of gases in sewage and the viscosity of sewage, which in turn affects these dimentation process in its treatment. Average temperature was recorded as 17.3 for Influent of STP Not much variation was found in temperature of Influent for all the three STP's. Also Average temperature value of the Effluent for all the three STP's were under Permissible Limit according to CPCB Effluent Discharge Standards into Inland Surface water.

3) Total Suspended Solids(TSS) and Total Dissolved Solids (TDS)

Sewage normally contains very small amount of solids in relation to the huge quantity of water (99.9%). Solids in the sewage comprise of both: Organic as well as Inorganic solids. TDS and TSS are common indicators of polluted water and wastewater therefore these to parameters are must to determine. Also in overall performance of an STP they are considered as important parameters. More over TDS of the wastewater is of concern as it affects the reuse of wastewater for agricultural purposes, by decreasing the hydraulic conductivity of irrigated land. Average TSS and TDS value for the Influent of all the three STP's indicated much variation among the three STP's in terms of TSS value for the Influent, which is attributed to large difference in the organic and inorganic loading of solids with liquid content in all the three STP's. Also Average TSS value of the Effluent for all the three STP's were under Permissible Limit according to CPCB Effluent Discharge Standards into Inland Surface water.

4) Biochemical Oxygen Demand (BOD)

The measure of biodegradable organic matter present in a water sample and can be defined as the amount of oxygen required by the microbes in stabilizing the biologically degradable organic matter under aerobic condition. Can be used as a measure of waste strength in terms of oxygen required. Moreover BOD is the most essential parameter which is considered to define the overall performance or efficiency of an STP.

It was observed that average BOD value for Effluent of STP was not under permissible limit according to CPCB Effluent Discharge Standards into Inland Surface water.

5) Chemical Oxygen Demand (COD)

A measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation by a strong chemical oxidant and thus is an index of organic pollution in the river. COD determination is considered important because it is widely used for measuring the pollution strength of wastewater. Highest value of COD was due to the heavy organic loading with less amount of water. Not much variation was found in COD value. It has been observed that average COD value for Effluent of STP was under permissible limit according to CPCB Effluent Discharge Standards into Inland Surface water.

6) Chloride (Cl-)

When the chloride content of a given sewage is found to be high, it indicates the presence of industrial wastes or infiltration of seawater, thereby indicating the strength of sewage. In the present study Cl- value varies from 169-192mg/L, 11-147 mg/L and 158-14mg/L for the Influent of STP. Average Influent value of Cl- recorded was 180.6 mg/L. Not much variation was found in Cl- value for the Influent which indicates that there is no presence of industrial waste or infiltration of sea water which generally attributes to the strength of sewage. It was observed that average Cl- value for Effluent of STP was under permissible limit according to CPCB Effluent Discharge Standards into Inland Surface water.

7) Nitrates

Presence of nitrates in the wastewater is one of the indicators of contact with human wastes. The value was recorded in the range of 1.7 mg/L for the Influent of STP. Average Influent value recorded was 3.1 mg/L, 4.1 mg/L. Moreover, Average Effluent value for NO3– N of STP's was under permissible limit according to CPCB Effluent Discharge Standards into Inland Surface water.

VIII. SCOPE FOR FUTURE STUDY

Investigate advanced sludge treatment methods, including thermal hydrolysis, pyrolysis, and gasification, to reduce sludge volume and improve dewaterability, Investigate the use of nanomaterials for enhancing pollutant removal efficiency, particularly for micropollutants and emerging contaminants, Study strategies to optimize energy consumption in sewage treatment plants, including energy-efficient aeration systems and process optimization, Study the potential for valorizing sewage sludge into biochar, construction materials, or biofuels, enhancing the sustainability of sludge management practices etc.and many more areas need further investigation.

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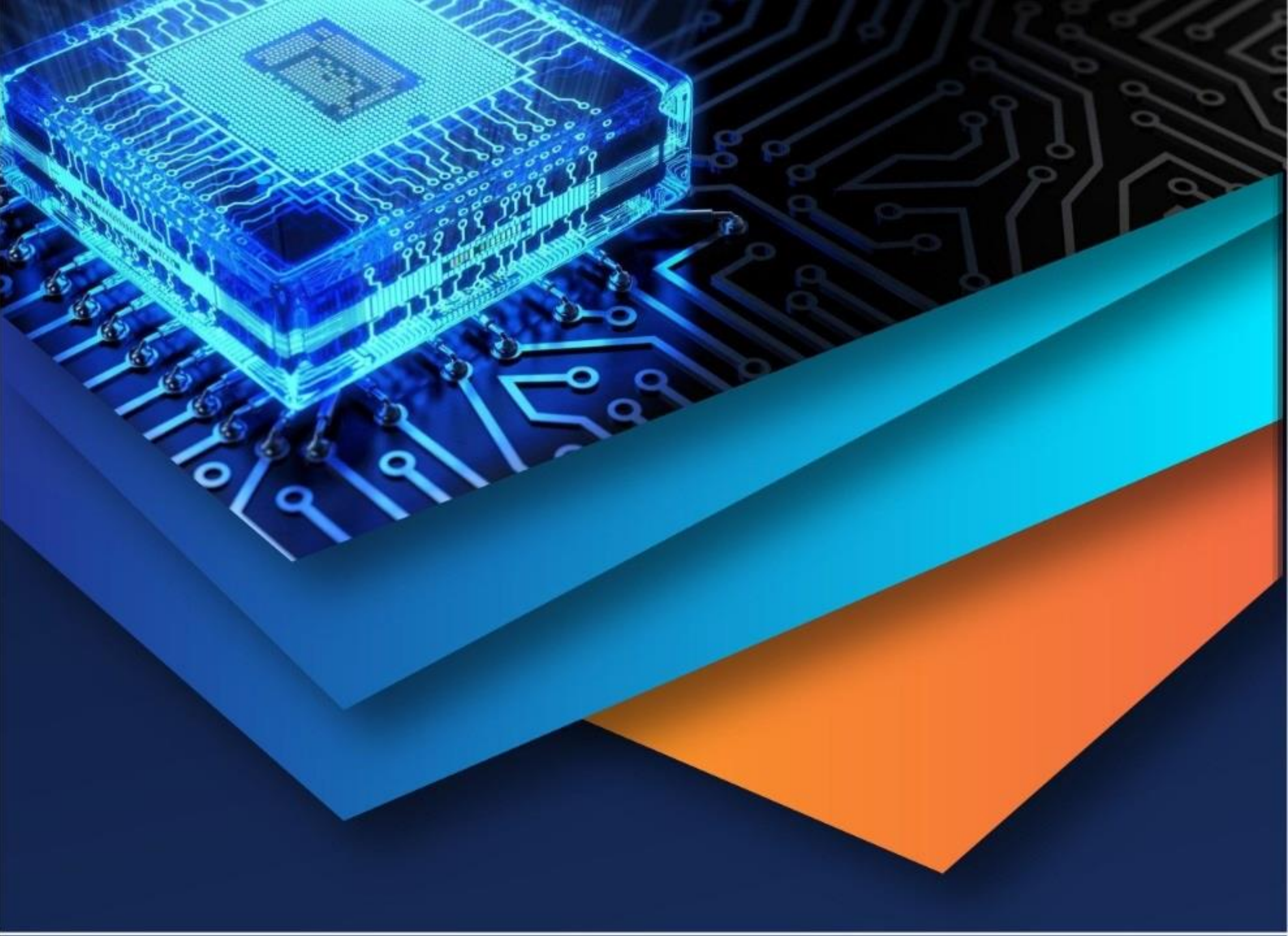

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