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ANALYSIS OF TREATED WATER SAMPLES FROM SEWAGE AND EFFLUENT TREATMENT PLANTS BY PHYSICO-CHEMICAL METHODS: A COMPARITIVE STUDY

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ABSTRACT:
Wastewater can be a valuable resource in cities or towns where population is growing and water supplies are limited. In addition to easing the strain on limited freshwater supplies, the reuse of wastewater can improve the quality of streams and lakes by reducing the effluent discharges that they receive. In the present investigation an attempt has been made to access the physical and chemical parameters of treated wastewater collected from sewage treatment plant, Sample-1 (domestic sewage) and effluent treatment plant, Sample-2 (industrial effluent) for pH, conductance, chemical oxygen demand (COD), biological oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), ammonical nitrogen and Kjeldahl nitrogen. The physical parameter pH was within the permissible limit but conductance was little high which shows presence of high amounts of inorganic compounds. The chemical parameters like chemical oxygen demand, total dissolved solids and organic nitrogen are within the permissible limit but biochemical oxygen demand, total suspended solids and ammonia are higher than permissible limit. The TSS values of sample-1 and sample-2 are very high and they needs to be completely treated before discharge into any water body. In sample-1 few parameters are within the limit and few are above the permissible limit, hence the sample needs more treatment via secondary and tertiary treatment methods.

Keywords: Domestic sewage, Industrial effluent, Sewage effluent, Total dissolved solids, Total suspended solids.

INTRODUCTION

Wastewater is the polluted form of water generated from rainwater runoff and human activities. It is also called sewage. It is typically categorized by the manner in which it is generated-specifically, as domestic wastewater from households, municipal wastewater from communities, industrial wastewater (effluents) from manufacturing and chemical processes and storm wastewater from runoff of precipitation that is collected in a system of pipes or open channels. Wastewater can contain physical, chemical and biological pollutants [1]. Domestic activities includes human excreta (feces and urine) often mixed with used toilet paper or wet wipes known as black water, washing dishes also known as grey water, surplus manufactured liquids from domestic sources such as drinks, cooking oil, pesticides, lubricating oil, paint and cleaning detergents [2, 7].

Wastewater is treated in wastewater treatment plants which include physical, chemical and biological treatment processes. Domestic wastewater is treated in sewage treatment plants and industrial wastewater is treated in effluent or industrial treatment plants and agricultural wastewater is treated in agricultural treatment plants. There are three levels of wastewater treatments namely primary treatment, secondary treatment and tertiary treatment. Primary treatment removes about 60 percent of total suspended solids and about 35 percent of BOD, dissolved impurities are not removed. Secondary treatment removes more than 85 percent of both suspended solids and BOD [3]. A minimum level of secondary treatment is usually required in United States and other developed countries. Tertiary treatment can remove more than 99 percent of all impurities from sewage, producing an effluent of almost drinking water quality [4]. For all levels of wastewater treatment, the last step prior to discharge of the sewage effluent into a water body is disinfection, which destroys any remaining pathogens in the effluent and protect spublic health [5].

Treated wastewater can be reused in industry (for cooling towers), in artificial recharge of aquifers, in agriculture and in the rehabilitation of natural ecosystems (wetlands). In rare cases it is also used to augment drinking water supplies [6]. There are several technologies used to treat wastewater for reuse. A combination of these technologies can meet strict treatment standards and make sure that the processed water is hygienically safe, meaning free from bacteria and viruses [8]. The following are some of the typical technologies: Ozonation, Ultra-filtration, aerobic treatment (membrane bioreactor), forward osmosis, reverse osmosis, advanced oxidation.

Wastewater can be a valuable resource in cities or towns where population is growing and water supplies are limited. In addition to easing the strain on limited freshwater supplies, the reuse of wastewater can improve the quality of

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streams and lakes by reducing the effluent discharges that they receive. Wastewater may be reclaimed and reused for crop and landscape irrigation, groundwater recharge or recreational purposes. Reclamation for drinking is technically possible but this reuse faces significant public resistance [9]. Some water demanding activities do not require high grade water. In this case, wastewater can bereused with little or no treatment. One example of this scenario is in the domestic environment where toilets can be flushed using grey water from baths and showers with little or no treatment.
Irrigation with recycled wastewater can also serve to fertilize plants if it contains nutrients, such as nitrogen, phosphorus and potassium. In developing countries, agriculture is using untreated wastewater for irrigation-often in an unsafe manner. There can be significant health hazards related to using untreated wastewater in agriculture. The World Health Organization developed guidelines for safe use of wastewater in 2006.
Various workers have conducted research on industrial wastewater effluents. Such as innovative approaches and new methodologies for protecting public health, recovering nutrient resources and protecting water resources from pollution are necessary [10, 11, 12]. Integrated, zero-discharge and waste water reuse strategies are the emerging concept in municipal waste water reuse at this time and development and dissemination of viable alternatives for urban waste water reuse is essential [13].
In the present study an attempt has been made to access the physical and chemical parameters of treated wastewater collected from sewage treatment plant (domestic sewage) and effluent treatment plant (industrial effluent) of Mysuru region. They are pH, conductance, chemical oxygen demand (COD), biologicaloxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), ammonical nitrogen and Kjeldahl nitrogen.

MATERIALS AND METHODS

Sampling and preservation: For the analysis of water samples, the sampling includes physical removal of samples from the target population and preserving the samples for analysis.

Sample collection: The sampling and analysis of industrial effluents require great care. It is therefore advisable to study during sample collection, the character of effluents, the waste load, major sources of wastes within a plant, recovery of useful materials and the effect of discharged wastes on the receiving body of water. Industrial effluents are subjected to rapid changes due to breakdowns, spills, floor washings and numerous other causes. So suitable sampling points, the frequency andtype of sample to be collected should be selected first. Generally, sampling points are located where flow conditions encourage a homogeneous mixture. Sampling sewage involves the collection of grab samples in a bottle of capacity 1 liter and combining them in a single container after 24 hour period. Shorter the time between collection and analysis, the more accurate will be the result.

Preservation of the sample: Preservation is essential to protect samples from changes in composition, deterioration with ageing, retarding biological action, reduction of volatility of constituents and for accurate results. Water samples should be preserved in polythene or glass bottles.

Sample containers: All the glass wares, conical flasks were first cleaned with de-ionized distilled water. The pipettes and burettes were rinsed with solution before final use. The used chemicals and the reagentswere of analytical grade reagent. The polythene bottles were thoroughly cleaned and washed with distilled water. They were capped and sealed with paraffin wax.
Water samples from sewage treatment plant and effluent treatment plant were collected in a polythene bottles. Two liters of sample was sufficient for the analysis of physico-chemical parameters. Standard methods were used for the determination. Analysis was carried out for various water quality parameters

1. **Determination of pH:** Calibrate the instrument with pH 4, 7, 9.2 buffer solutions. Rinse the electrode with distilled water, shake off excess water. Immerse the electrode into the sample, wait for 30 seconds for stable reading. Record the reading.

2. **Determination of conductance:** Take the water sample in the beaker. Warm up the instrument and calibrate the meter with 0.01 M KCl. Adjust cell constant and temperature of the conductivity meter. Rinse the conductivity cell with distilled water and then with the sample. Connect the conductivity cell to meter and dip in the sample. Adjust the current by rotating the dial so that maximum sensitivity is obtained. Read the conductivity value in micro S/cm. direct reading may be obtained by digitalmeters [14].

3. **Determination of Chemical Oxygen Demand (COD):** Place 0.4 g of mercuric sulfate in a reflux flask and add 20 ml of the sample or an aliquot of the sample diluted to 20 ml with distilled water. Mix well and add 10 ml of 0.25 N potassium dichromate solution. Drop some pumice stones and slowly add 30 ml of sulfuric acid-silver sulfate reagent while continuously swirling the flask. If the color changes to green add more dichromate and reagent or alternatively discard the solution and take fresh sample with lesser aliquot. Mix the contents of the flask thoroughly. Connect the flask to the condenser and slowly heat. Reflux for at least 2 hours. Cool and wash down the condenser with distilled water suchthat the washings fall into the flask. Dilute to about 150 ml, cool and titrate the unreacted potassium dichromate with N/10 ferrous ammonium sulfate solution using ferroin as indicator. The

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color change at the endpoint is from blue green to wine red. Perform the blank experiment with distilled water instead of the water sample [15]. The COD of the sample is calculated by **COD in mg/L = (A-B) * N *8 *1000 / x**

Where, A = Volume of ferrous ammonium sulfate run down in the blank experiment.B = Volume of ferrous ammonium sulfate run down in the test experiment.
N = Normality of ferrous ammonium sulfate solution andx = Volume of test sample taken.

4. **Determination of Biochemical Oxygen Demand (BOD):** Redistill water in presence of a little alkaline permanganate. Store this double distilled water in a BOD incubator at 20^{O}C. Aerate the required quantity of this distilled water at 20 ^{O}C with clean compressed air. Add 1 ml each of calcium chloride, magnesium sulfate, ferric chloride and phosphate buffer solutions per liter to the above aerated distilled water and mix thoroughly. This standard dilution water should be prepared just before use. The addition of small measured volume of water containing a good bacterial population to the dilution water is called seeding. Seeding is not required for sewage and sewage effluents because they contain the bacterial flora [16]. Seeding is necessary for industrial effluents which generally do not contain any bacteria. The seed should be kept for 1 to 2 days at 20 ^{O}C before use. The seed concentration recommended is 1 to 2 ml per liter of dilution water.

5. **Determination of DO: Winkler's method:** Take aliquot sample in duplicate in 300 ml BOD bottles and fill with distilled water. Incubate one bottle at 27 ^{O}C for 3 days. To the other bottle, add 2 ml of manganous sulfate solution followed by the addition of 2ml of alkali-iodide-azide solution. Stopper carefully to exclude air bubbles and mix by inverting bottle few times. Allow the precipitate to settle to leave clear supernatant above the brown colored manganese oxi-hydroxide floc. Carefully remove the stopper and add 2 ml of concentrated sulfuric acid by the side of thebottle to make the brown precipitate dissolve completely resulting in a clear yellowish brown solution. Now take 200 ml of this clear yellowish brown solution and titrate against 0.025N sodium thiosulfate solution to a pale yellow color. Add few drops of starch indicator and continue titration to first disappearance of blue color to colorless. Carry out same procedure for the blank also, without having the sample solution. It is carried out to estimate zero day DO. After 3 days of incubation, same above procedure is repeated to estimate third day DO. Exclude light to avoid growth of algae in the bottles during incubation.

The BOD of the sample can be calculated by BOD (mg/L) = (Initial DO - Final DO) *1000 / Volume of sample.

6. **Determination of Total Dissolved Solids (TDS):** Heat the TDS bowl to 180°C for one hour in an oven. Store in desiccators till the bowl cools completely. Weigh immediately before use. Filter 25 ml of well mixed sample. The filtered sample is transferred to pre-weighed TDSbowl and placed on a steam bath for complete evaporation. After complete evaporation the dish is transferred to the oven which is kept at 180°C forone hour. Remove the dish from oven and cool in desiccators. Now weigh the cooled dish and repeat this drying, cooling desiccating cycle until aconstant weight is obtained. The TDS of the sample can be calculated by TDS (mg / L) = (A - B) * 1000 * 1000 / Volume of the sample Where A = final dish weight with residue B =initial dish weight (empty dish).

7. **Determination of Total Suspended Solids (TSS):** Heat the cleaned sintered glass crucible in an oven for an hour to about 103 to 105°C. Remove the crucible from oven after one hour and cooled in desiccator. Now transfer well mixed sample to the cooled sintered glass crucible and filter using filtration apparatus. After filtration keep the crucible in an oven for one hour and then cooled in a desiccator. The weight of the crucible along with the sample was noted. Repeat the process of drying, cooling, filtration and weighing to get constant weight. The TSS of the sample can be calculated by TSS (mg / L) = (A-B) * 1000 * 1000 / Volume of the sample, Where A = final weight of the sintered glass crucible along with residue B = initial weight of the sintered glass crucible, TSS = (TS - TDS), Where TS= total solids, TDS = total dissolved solids.

8. **Determination of Total Solids (TS):** Heat the clean evaporating dish for one hour in an oven kept at 103 to 105°C. Cool the dish in the desiccator. Weigh immediately before use. Take suitable volume of well mixed sample in a dish and evaporate on steam bath. After complete evaporation of water from the residue, transfer the dish to an oven at 103 to 105°C dried to constant mass. Transfer the dish to desiccator and cool and take the final weight of the dish along with the residue. The TS of the sample can be calculated by TS (mg / L) = (A-B) * 1000 * 1000 / Volume of the sample, Where A = final weight of the dish along with residueB = initial weight of the dish

9. **Determination of Ammonical Nitrogen (AN):** Take suitable volume of well mixed sample in distillation flask and diluted to 200 ml. Add 25 ml of 4 % boric acid solution to maintain the pH and add 15 - 20 ml of 40 % sodium hydroxide solution. To the above solution add 4 drops of mixed indicator. Place the flask in its proper position in distillation apparatus and turn on heating. Collect about 200 ml distillate and remove the flask. Now titrate the distillate with 0.02 Nsulfuric acid. End point shows dark green to pale lavender color. Carry out a blank through

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above steps. The ammonical nitrogen present in the sample is calculated by AN (mg / L) = (A - B) * 14 * 1000 * N / V,

Where A = Titrate value of the sampleB = Titrate value of the blank
V = Volume of the sample takenN = Normality of sulfuric acid

10. **Determination of Organic Nitrogen (ON):** Take 100 ml of the sample or suitable volume of well mixed sample in kjeldahl flask. Add the digestion mixture to the flask. Heat the flask gently in a slightly inclined position for 3 hours. Now remove the flask and allow to cool, after cooling add the hypo solution to the mixture. Take 5 ml of 1 % boric acid solution containing two drops of mixed indicator in a conical flask. Place the flask below the condenser so that the tip of outlet of the condenser is dropped incontents of the flask. Continue distillation for 10 minutes. Remove the conical flask having distillate. Titrate the distillate against 0.02 N Sulfuric acid solution till the color changes from blue topink. Run the blank using distilled water in the similar manner. The organic nitrogen present in the sample is calculated by ON (mg / L) = (A - B) * 14 * 1000 * N / V

Where A = Titrate value of the sampleB = Titrate value of the blank N = Normality of sulfuric acid
V = Volume of the sample taken

RESULT AND DISCUSSION:

pH is the hydrogen ion activity and a measure of acidity and alkalinity in aquatic bodies. The sample-1 from sewage treatment plant (domestic sewage) and sample-2 from effluent treatment plant (industrial effluent) of Mysuru region exhibited 7.82 and 6.34 respectively as shown in table 1. The values of pH are within the permissible limit. The pH above 7.0, will indicate that water is probably hard and contains calcium and magnesium. Table 1 gives the comparison of physico-chemical parameters of Sample-1 and Sample-2. Specific conductance is an easily obtained parameter that is a good indicator of the amount ofdissolved solids in water and thus can be used to detect contaminants in water. The permissible limit for conductance of treated water is 600-2250 S/m. The conductivity of sample-1 and sample-2 are 2330 S/cm and 2200 S/cm respectively (table 1). The conductivity of sample-1is little high than the permissible limit, so the sample-1 is not treated well and has high amountof inorganic compounds. The conductivity of sample-2 is within the permissible limit and hence can be released to water bodies.

In the case of biodegradable organics, the COD is normally in the range of 1.3-1.5 times of BOD. When the result of a COD test is more than twice that of BOD test, there is good reason to suspect that a significant portion of the organic material in the sample is not biodegradable by ordinary microorganisms. Municipal waste water consumes oxygen in the range from 300-1000 mg/L. After treatment, the COD drops to 20-1000 mg/L. The permissible limit for the release of treated water to natural waters is less than 300 mg/L. The COD values of sample-1 and sample-2 are 284 mg/L and 1376mg/L respectively. Sample-1 is within the limit but sample-2 has high COD value than the permissible limit, so it is not fit to be released to water bodies because of high concentration of organic matter. But it can be utilized for irrigation and for household chores.

Table: 1. Comparison of physico-chemical parameters of Sample-1 and Sample-2

PARAMETER	SAMPLE 1 [SEWAGE] in mg/L	SAMPLE 2 [EFFLUENT] in mg/L	PERMISSIBLE LIMIT in mg/L
PH	7.82	6.34	6-9
CONDUCTANCE	2330 S/cm	2200 S/cm	<2250 S/cm
COD	284	1376	<300
BOD	90	640	<40
TDS	792	2000	<2100
TSS	184	424	<100
AN	129.2	0.576	<50
ON	28.56	142.24	<35-40

The permissible limit of BOD is below 40 mg/L. The BOD values of sample-1 and sample-2 are 90 mg/L and 640 mg/L respectively. These values of BOD of both the samples are very higher than the permissible limit, hence its not safe to release both the samples to water bodies because it causes adverse effect on aquatic species. The samples are not completely treated. They have undergone only primary treatment process; hence they need to be treated by secondary treatment process which removes more than 85% of BOD.

TDS affect water taste and often indicates a high alkalinity or hardness. High concentrations may decrease photosynthesis, combine with toxic compounds and heavy metals and lead to an increase in water temperature. The permissible limit of TDS is less than 2100 mg/L. Total dissolved solids values of sample-1 and sample-2 are 792 mg/L and 2000 mg/L respectively. The values of both the samples are within the limits, so they are safe to be released to

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water bodies.
The permissible limit of TSS is within 100 mg/L. The TSS values of sample-1 and sample-2 are 184 mg/L and 424 mg/L respectively. The values are very high and they needs to be completely treated before discharge into any water body. High TSS can also cause increase in surface water temperature, because the suspended particles absorb heat from sunlight and cause further decrease in oxygen level.
Ammonia is also one of the important pollutant because it is relatively common but can be toxic, causing lower reproduction and growth. The neutral and unionized form of ammonia is highly toxic to fish and other aquatic life. The permissible limit of ammonia is 50 mg/L. The values of ammonia for sample-1 and sample- 2 are 129.2 mg/L and 0.576 mg/L respectively. Sample-1 has higher value of ammonia so it cannot be discharged to water, but sample-2 has values within the limit hence they can be discharged into water bodies.
Total kjeldahl nitrogen which is the sum of ammonia nitrogen and organically bound nitrogen. Natural biochemical processes slowly convert the organic nitrogen into ammonia, which is the form of nitrogen best able to be utilized as a nutrient by microorganism in treatment process. The permissible limit of organic nitrogen is 35 mg/L. The values of organic nitrogen for sample- 1 and sample-2 are 28.56 mg/L and 142.24 mg/L respectively. The value for sample-1 is within the limit but that of sample-2 its very high than the permissible limit. Therefore sample-1 can be discharged into water bodies but sample-2 cannot be discharged as it causes death of aquatic life.

CONCLUSION:

The present study was undertaken with an aim to analyze the physical and chemical parametersof the water samples collected from sewage treatment plant (sample-1) and effluent treatment plant (sample-2). The physical parameter pH was within the permissible limit but conductance was little high which shows presence of high amounts of inorganic compounds. The chemical parameters like chemical oxygen demand, total dissolved solids and organic nitrogen are within the permissible limit but biochemical oxygen demand, total suspended solids and ammonia are higher than permissible limit. TSS and TDS give the quality of water sample; biochemical oxygen demand gives the amount of organic matter present in sample; chemical oxygen demand represents the both organic and inorganic matter present in water sample. In sample-1 few parameters are within the limit and few are above the permissible limit hence the sample needs more treatment via secondary and tertiary treatment methods.

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