International Journal of Environment and Climate Change

Volume 14, Issue 4, Page 69-79, 2024; Article no.IJECC.113966
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Assessment of Physicochemical Quality and Challenges of Municipal Sewage Water in Manchalapur Village in the Karnataka, India

Kavitha [a*] and Prasad S. Kulkarni [b]

[a] College of Agricultural Engineering, University of Agricultural Sciences, Raichur-584101, India.
[b] Department of Irrigation and Drainage Engineering, College of Agriculture Engineering, University of Agricultural Sciences, Raichur-584101, India.

Authors' contributions

This work was carried out in collaboration between both authors. Author Kavitha carried out proposal development, survey analysis, review of literature, collected water samples, analyzed and documented the study. Author PSK played the role of effective supervision and guidance on the procedures for sample collection and analysis as well as reviewed the whole project report. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2024/v14i44097

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/113966

Original Research Article

Received: 12/01/2024
Accepted: 16/03/2024
Published: 04/04/2024

ABSTRACT

The present study was carried out on characterization of municipal sewage water tank of Manchalapur village near Raichur city in Karnataka. The water samples were collectedeight times from four different locations like inlet, outlet and water spreading area of the Manchalapur tank during the year 2018-2019 in monsoon and post monsoon season. The collected water samples were analyzed for the water quality parameters by using standard procedure. The results obtained were compared with Central Pollution Control Board (CPCB) and Bureau of India Standards (IS 2296:1992) water quality requirements for irrigation. The results showed that pH (7.89, 8.54),

**Corresponding author: E-mail: khiremath79@gmail.com;*

Electrical Conductivity (1.41, 1.48 dSm^{-1}), Total Dissolved Solids (929.63, 1031.56 mg L^{-1}), Carbonate (2.15, 0.86 mg L^{-1}), Bicarbonate (7.71,4.99 mg L^{-1}), Nitrate (26.90, 34.09 mg L^{-1}), Phosphate (9.85, 6.20 mg L^{-1}), Calcium (3.38, 2.77 mg L^{-1}), magnesium (5.16, 4.13 mg L^{-1}), Sodium (0.85, 0.92 mg L^{-1}), Biological Oxygen Demand (1396.88, 1252.31 mg L^{-1}), Chemical Oxygen Demand (14480, 8573.0 mg L^{-1}), Dissolved Oxygen (7.91, 8.02 mg L^{-1}) and turbidity (13.33, 8.77 NTU) for monsoon and post monsoon respectively. All the water quality parameters were within the recommended range of irrigation standards except the parameters BOD, COD, DO and turbidity. The results could be applicable advice to farmers and agricultural researchers for proper management and use of tank water for agricultural purpose.

Keywords: Municipal sewage; irrigation; water samples; monsoon; post monsoon.

1. INTRODUCTION

“Water is essential for all human activities and this is facing increasing strain due to growing populations demanding high-quality water for both domestic and economic needs. Better management of freshwater quality is a top environmental priority in India this century, with surface water sources experiencing heightened pressure due to population growth. Tank irrigation, an ancient practice in India, is particularly significant in the southern parts of the country, where average annual rainfall is around 700 mm. There are about 127,000 tanks in the southern region consisting of Andhra Pradesh, Tamil Nadu and Karnataka states” [1].

“Approximately 20 million hectares of agricultural land worldwide are irrigated with treated or untreated wastewater, with a growing necessity for its use in developing countries. Factors driving this expansion include rising water stress, urbanization, increasing urban wastewater flows, and more urban households participating in agricultural activities that could benefit from additional irrigation water sources” [2].

The increasing reliance on agricultural wastewater encounters a notable obstacle due to its dependency on either untreated wastewater or polluted river and streams.Limited availability and high costs of freshwater, coupled with inadequate wastewater treatment infrastructure to accommodate urban growth, leave urban farmers with little choice but to use highly contaminated water for their agricultural needs [3,4]. This scenario presents a particularly tough challenge for urban communities with limited financial resources, as they heavily rely on agriculture for their income, employment, and food security. It underscores the complex relationship between water resources, urban development, and poverty [5,6].

2. MATERIALS AND METHODS

2.1 Study Area

The research was carried out in the vicinity of Raichur, which is situated between the Krishna and Tungabhadra rivers. The Raichur district's administrative center is Raichur. Manchalapur Tank, the study area, is ten kilometers from Raichur City.The study area is 380 meters above mean sea level and is located in Karnataka's North-Eastern Dry Zone (Zone-2) at latitudes 16° 14'N and longitude 77° 19'E. Rainfall in the area averages 875.3 mm. The region's monthly mean maximum and minimum temperatures are 44.34°C and 10.39°C, respectively, in May and January. The current water tank was frequently utilized for home purposes, fish farming, and irrigation.

2.2 Collection of Water Sample

Polyethylene bottles were used to gather water samples from the Manchalapur tank's outlet, two locations within the tanks' water spreading area, and the tank's inlet where sewage enters (Fig. 1). The water samples were taken in medical-grade autoclavable polyethylene bottles with a capacity of 250 ml during the post-monsoon (November to February) and monsoon (June to October), and they were refrigerated at 4°C.

2.3 Water Quality Analysis

The samples were analysed in the laboratory (Plate 8) using standard procedure (APHA, 1998) and Indian standards for all parameters and LaMotte Smart3 test procedure used for COD, mercury and surfactants analysis. Results were compared to Central Pollution Control Board (CPCB) and Bureau of India Standards (IS 2296:1992) water quality requirements for irrigation.

Fig. 1. Satellite image of the Manchalapur tank obtained from google earth

2.3.1 pH

The pH of a solution is the negative logarithm of hydrogen ion concentration. It is the measure of acidity or alkalinity of water. The pH value ranges from 0 to 14. The water with a pH less than 7 is considered acidic, and with a pH greater than 7 is considered as basic. The pH meter was first set to room temperature and calibrated using buffer solution having pH of 7.0. The pH was then determined by taking 50 ml water sample in a 100 ml clean beaker and immersing the electrodes of the pH meter in it (Jackson, 1973).

2.3.2 Electrical Conductivity (EC)

EC is the capacity of water carry an electrical current and varies both with number and types of ions the solution contain. The same samples used for the determination of pH were used again for determining the electrical conductivity (total soluble salts) of water samples. The EC was recorded using the EC meter and expressed in dS m-1 . The conductivity meter was first calibrated with conductivity standard (0.01 N KCl with conductivity 1.413 dS m^{-1}) (Jackson, 1973).

2.3.3 Total Dissolved Solids (TDS)

The TDS of the wastewater samples were determined by using TDS meter and expressed in mg $L^{-1.}$ The electrodes of TDS meter was inserted into the water sample and readings are recorded (APHA, 1998).

2.3.4 Estimation of anions

Most important anions from water quality point of view were carbonate and bicarbonate. Carbonates and bicarbonates (CO_3 and HCO_3) were determined by titrimetric method using sulphuric acid (0.1 N). 3.10.5 Estimation of nitrates and phosphates Domestic sewage contains an appreciable amount of nutrients, and determined by following standard methods. Nitrate nitrogen (NO3--N) was estimated by titrimetric method after Kjeldhal distillation as per APHA standard method for examination of wastewater (APHA, 1999). Phosphate estimation was done by Stannous chloride method using spectrophotometer (APHA, 1999).

Table 1. Standard methods used for water quality parameter analysis

Sl. No.	Parameter	Methods	Bureau of India Standards (IS 2296:1992) Irrigation water quality standards	Units	Reference
1	pH	Glass electrode	6.5-8.5	-	Jackson, 1973
2	Electrical Conductivity	Conductivity bridge	2.0	dS m^{-1}	Jackson, 1973
3	Total Dissolved Solids	Gravimetric	2100	mg L^{-1}	APHA, 1998
4	Carbonates and Bicarbonates	Titrimetric	-	meq L^{-1}	APHA, 1998
5	Nitrate	Kjeldhal	50	mg L^{-1}	APHA,1999
6	Phosphate	Stannous chloride	-	mg L^{-1}	APHA, 1999
7	Calcium and magnesium	Versante Tiration	-	mg L^{-1}	APHA, 1998
8	BOD5	Incubation	100	mg L^{-1}	APHA, 1998
9	COD	Mercury free digestion	-	mg L^{-1}	APHA, 1999
10	DO	Titrimetric	6	mg L^{-1}	APHA, 1998
11	Turbidity	Nephelometric	-	NTU	APHA, 1998

2.3.5 Estimation of cations

The main cations estimated for wastewater were calcium, magnesium and sodium. The calcium and magnesium concentrations were determined by complex-metric titration using disodium solution of ethylene diamine tetra acetic acid (EDTA) method. Sodium was determined by flame photometric method (APHA, 1998).

2.3.6 Biochemical Oxygen Demand (BOD5)

The BOD5 of the water samples were analyzed using the "VELP Scientifica" BOD Sensor System. It was assumed that nutrients, such as nitrogen, phosphorus and micronutrients, were absent in sufficient amounts for a regular development of bacterial flora. In these cases, it was necessary to add nutrients by using solutions (A, B, C and D) prepared as per standard methods (APHA, 1999). BOD5 measurement with BOD Sensor was based on the respirometric method that provided direct measurement of the oxygen consumed by microorganisms from an air or oxygen-enriched environment in a closed atmosphere (an incubator), at constant temperature (20°C ± 0.5) and with a soft sample stirring by placing a magnetic stirring bar in the 500 ml dark glass bottle with water sample, for 5 days. The technical specifications are given in Appendix A1. Distilled water of the same volume was introduced into another incubation bottle as blank. 1 mL each of solutions A, B, C and D was added to the setup. A magnetic stirring bar was placed in the solution in the incubation bottles and fitted with a plastic container filled with 10 pellets of potassium hydroxide (KOH) before the sensor was screwed on top of the bottle. The incubator used for the analysis of BOD5 show in plate 6. This was kept for 5 days in an incubator at 20°C and real BOD5 values were calculated from the digital sensor display as follows.

$$BOD5 = (Ss - SDW) \times DF \quad (3.10)$$

where, BOD5 = Biochemical Oxygen Demand for 5 days at 20°C (mg L^{-1})

Ss = Sensor reading of incubation bottle filled with sample

SDW = Sensor reading of incubation bottle with distilled water

DF = Dilution factor

The higher the value of BOD5 the greater will be the amount of organic matter or food available for oxygen consuming bacteria.

2.3.7 Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) of water samples was estimated by mercury-free digestion method (Code 0076-SC) as per the SMART3 test procedure using the LaMotte SMART3 colorimeter. Other materials used were COD standard range mercury free tubes, a COD reactor (110V) and a COD heater block.

2.3.8 Turbidity

The turbidity of wastewater samples collected from project site was estimated using the Nephelometric method and expressed as NTU as per standard method (APHA, 1999). The technical specifications are given in Appendix A2.

2.3.9 Dissolved Oxygen (DO)

The DO of water samples were measured by using DO meter. The probe of DO meter was first filled with an electrolyte and then calibrated with oxygen content in air (20.9 per cent).

3. RESULTS AND DISCUSSION

3.1 Physical Parameters

The municipal water samples (Manchalapur tank) that were collected during the study appeared blackish in colour at inlet and greenish colour at the outlet and tank water storage area. The greenish colour indicated the presences of the nutrients present in the water and increased the amount of phytoplankton productivity in the water. The blackish colour indicated the presence of the colloidal particles. The municiple water samples was inquired with an odd odour that may be due to the decomposition of organic matters present in the water over time or due to the septic contamination or addition of various chemicals.

3.2 Chemical Parameters

3.2.1 pH and electrical conductivity

The hydrogen ion (H+) activities that determine whether water is acidic or alkaline are measured by pH. As shown in Fig. 2, the mean pH measured in the Manchalapur tank was highest (8.15) in the post-monsoon season and lowest (7.89) in the monsoon season. Water used for irrigation should have a pH between 6.0 and 8.5. The findings indicate that the pH values obtained during both seasons fell within the suggested range. The presence of bicarbonate ions, which are created when CO2 and water combine to form carbonic acid, which alters the pH of the water, could be the cause of the water's slightly alkaline character [6].

The electrical conductivity of water provides information on the concentration of soluble salts. The mean electrical conductivity (EC) during the monsoon season (1.41dSm-1) and the post-monsoon season (1.48dSm-1).The findings indicate that, for irrigation purposes, the mean EC value for both seasons is found to be within the allowable limit standards. Carbonate minerals and other ionic species will dissolve less readily in water the lower the electrical conductivity value.

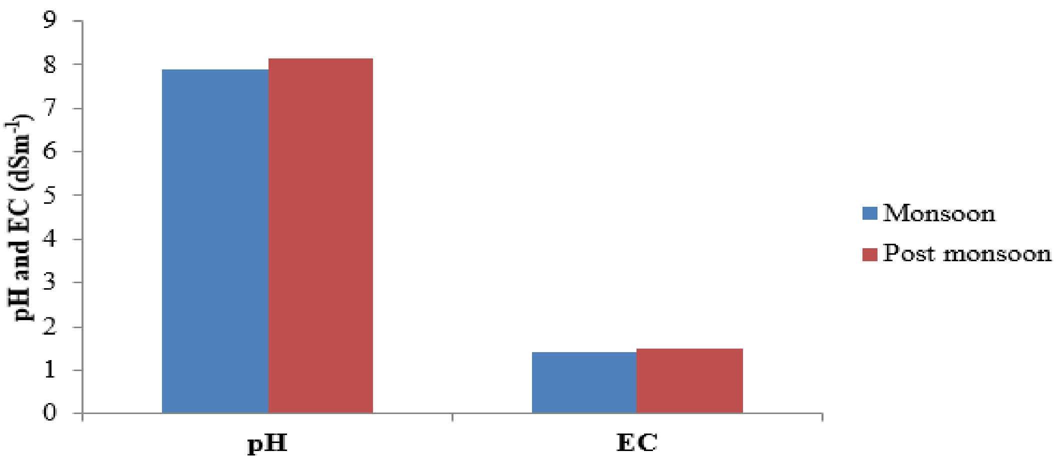

Fig. 2. Concentration of pH and EC (dS m^{-1}) of samples in monsoon and post monsoon season

3.2.2 Total Dissolved Solids (TDS)

Total dissolved solids (TDS) are the molecular and/or microgranular forms of all the inorganic and organic materials found in wastewater. As shown graphically in Fig. 3, the mean TDS value during the monsoon season was 929.63 mg L-1, and during the post-monsoon season was 1031.56 mg L-1. The outcome shows that the measured TDS is within the advised TDS range for irrigation. During the post-monsoon season, the average concentration of Total Dissolved Solids (TDS) was higher than during the monsoon season. This rise was ascribed to the post-monsoon period's addition of the same volume of municipal sewage to a lower volume of water [7].

3.2.3 CARBONATE AND BICARBONATE

As compared to the post-monsoon season, the mean carbonate and bicarbonate values were higher during the monsoon season, according to the results. The carbonate value was 2.15 meq L-1 during the monsoon season and 0.86 meq L-1 after it ended. Bicarbonate values were 4.49 meq L-1 and 7.71 meq L-1 during and after the monsoon, respectively (Fig. 4)

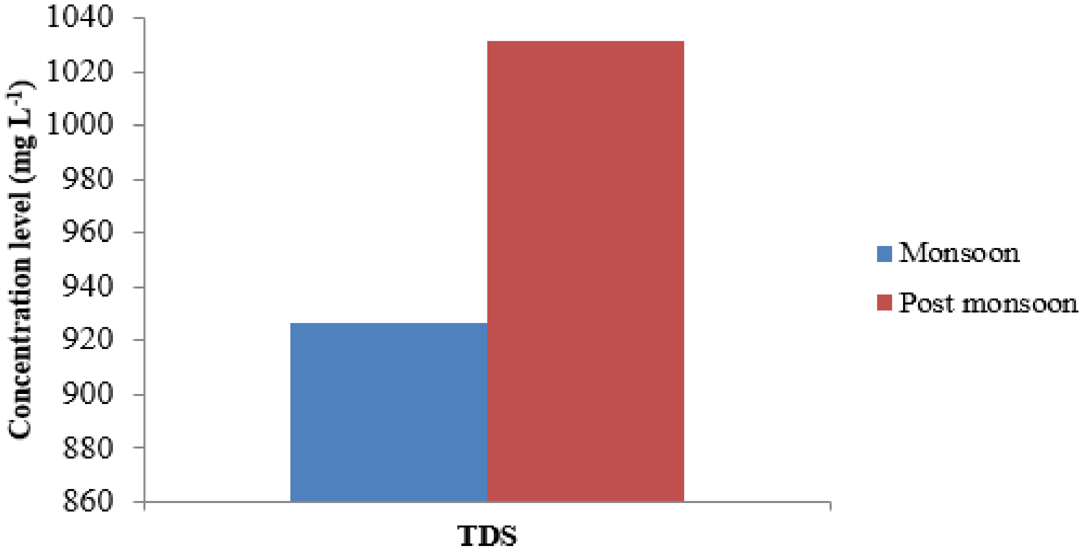

Fig. 3. Concentration of TDS of samples in monsoon and post monsoon season

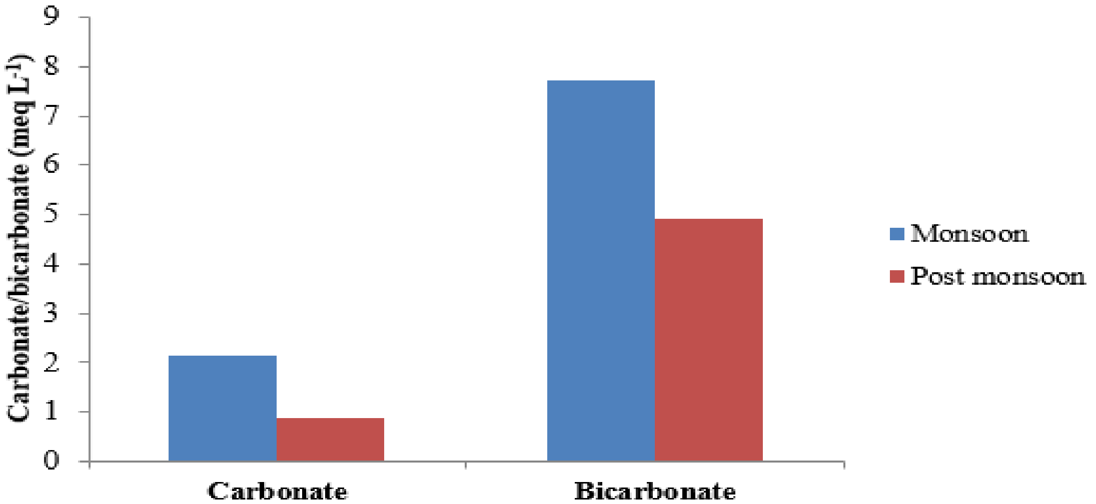

Fig. 4. Concentration of carbonate and bicarbonate (meq L^{-1}) of samples in monsoon and post monsoon season

3.2.4 Nitrate and phosphate

From the Fig. 5, the nitrate concentration was recorded lowest in monsoon season (26.90 mg L^{-1}) compared to post monsoon season (34.09 mg L^{-1}). The standard nitrate concentration for both drinking and irrigation water is 45 mg L^{-1}. The observed value is less than recommended value. The current study's water sample contains nitrate, which partially meets the nitrate needs of the plants. As a result, less nitrate was applied in the form of fertilizer.

"The mean phosphate level peaked during the monsoon season (9.85 mg L) and decreased during the post-monsoon season (6.20 mg L), as shown in Fig. 5. Due to the addition of domestic waste water, especially detergent-containing waste, and runoff from various sources containing fertilizers to the tank, the mean phosphate value was higher during the monsoon season than it was after" [6].

3.2.5 Concentration of cations

The cations sodium, magnesium, and calcium are found in water samples. The calcium concentration in the Manchalapur tank water was found to be 3.38 mg L^{-1} during the monsoon season and 2.77 mg L^{-1} in the post-monsoon season, while the magnesium concentration was found to be 5.16 mg L^{-1} during the monsoon season and 4.13 mg L^{-1} in the post-monsoon season, respectively (Fig. 6).

Low values do not imply that they are unaffected by pollutants; rather, they could be the result of the opposite cationic exchange with sodium. High values of calcium and magnesium are caused by the cationic exchange with sodium or by the home waste water and effluent present in the sewage. Between the monsoon and post-monsoon seasons, the sodium concentration was 0.85 mg L^{-1} and 0.92 mg L^{-1}, respectively.

3.2.6 Biochemical oxygen demand (Bod_5), chemical oxygen demand (Cod) and disolved oxygen (Do)

In the monsoon and post-monsoon seasons, the mean BOD5 was 1396.88 mg L^{-1} and 1252.31 mg L^{-1}, respectively. Both seasons' BOD levels seemed to be above the 100 mg L^{-1} irrigation standard.In the monsoon season, the mean COD recorded was the highest at 24549 mg L^{-1}, compared to 8573 mg L^{-1} in the post-monsoon seasons. Increased oxidizable organic material in the water sample is indicated by a higher COD level, which will lower the dissolved oxygen level. It resulted in the anaerobic environment. The mean DO value was 8.02 mg L^{-1} in the post-monsoon season and 7.91 mg L^{-1} during the

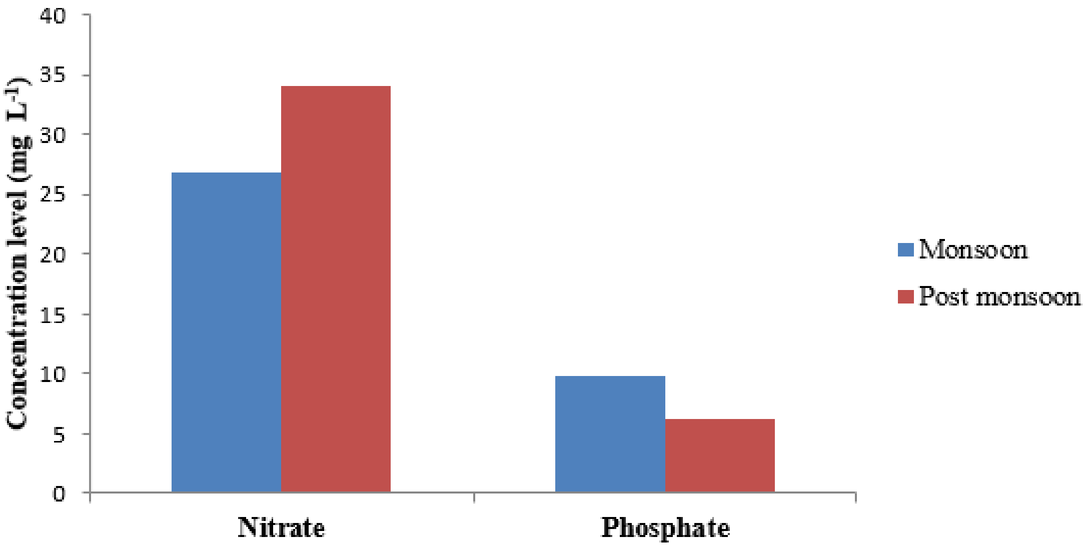

Fig. 5. Concentration of nitrate and phosphate (mg L^{-1}) of samples in monsoon and post monsoon season

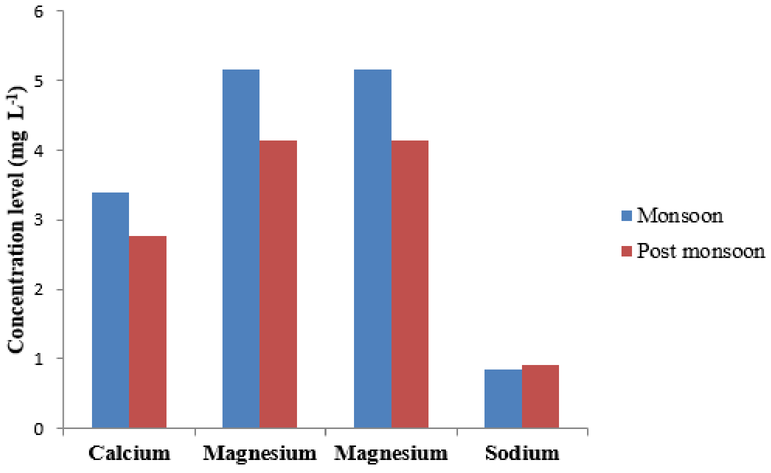

Fig. 6. Concentration of calcium, magnesium and sodium (mg L^{-1}) of samples in monsoon and post monsoon season

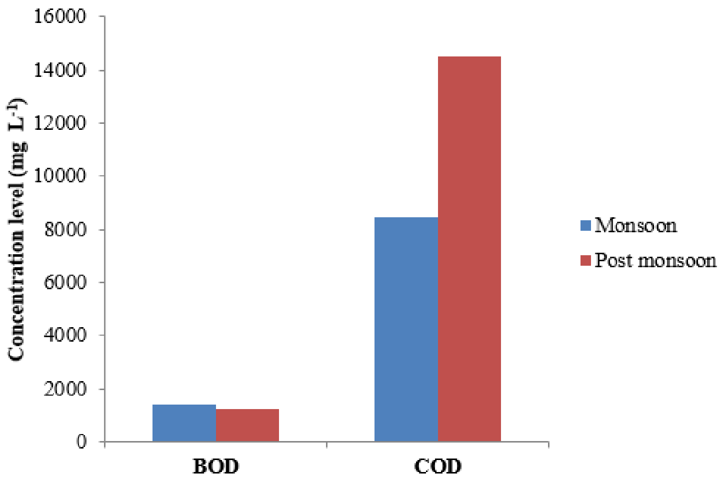

Fig. 7. Concentration BOD and COD (mg L^{-1}) of samples in monsoon and post monsoon season

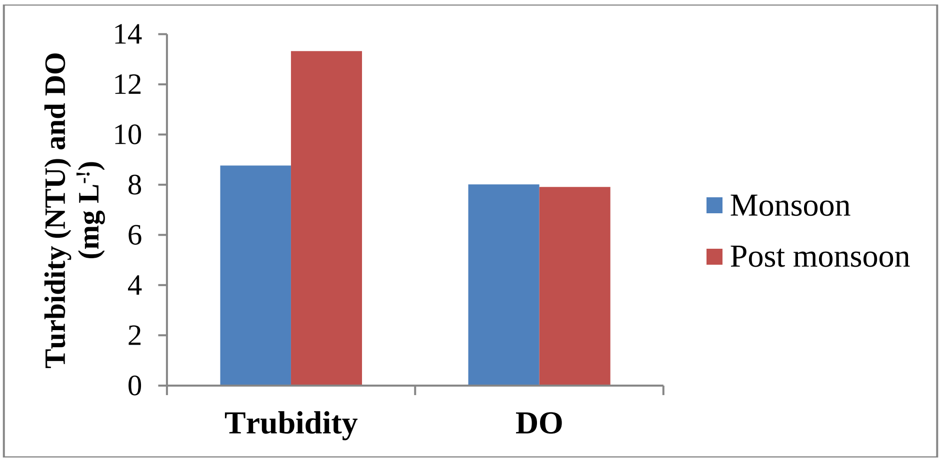

Fig. 8. Concentration turbidity (NTU) and DO (mg L^{-1}) of samples in monsoon and post monsoon season

monsoon season. The findings indicate that there was little variation in the mean DO value between the monsoon and post-monsoon periods.

3.2.7 Turbidity

The basic indicator of the amount of suspended solids in wastewater, turbidity is typically calculated using the light scattering principle. In comparison to the post-monsoon season (8.77 NTU), the mean turbidity value is higher during the monsoon season (13.33 NTU). The lack of runoff from the area during the post-monsoon season was the reason for the low turbidity of the water.

"Turbidity was found relatively high in monsoon season due to addition of dissolved fertilizers, pesticides, herbicides and other particles from the agriculture land to the tank" (Augustine et al, 2016).

"The mean turbidity value was high compared to the recommended value. The higher turbidity affects organisms that are directly dependent on light, like aquatic plants because it limits their ability to carry out photosynthesis. This in turn, affects fishes that depend on these plants for food and oxygen. Dissolved oxygen is an important parameter to indicate the purity and reactiveness of water" [8-15].

4. CONCLUSION

Water is essential for sustaining life, but increasing population, urbanization, and agricultural expansion have led to the deterioration of tank water quality. While quantity matters, the quality of water is equally crucial. Research findings indicate that all water quality parameters meet permissible irrigation standards, including dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), and turbidity. However, the high concentration of dissolved oxygen (>5 mg L-1) in tank water renders it unsafe for aquatic life. Although water samples used for irrigation contain anions such as nitrate and phosphate, meeting some agricultural requirements, the study concludes that water must be treated before being used for irrigation purposes. Treating sewage water for irrigation involves several steps to make sure it's safe for farming and doesn't harm people or the environment.

FUTURE SCOPE

In future the effect of municipal sewage water on surface water bodies and ground water near the study area can be studied.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ranjan P, Arya R. Tank irrigation – challenges and options, NRM term paper. National Resource Management, Xavier Institute of Management, Bhubaneshwar. 2008;8.
2. Scheierling MS, Bartone C, Mara DD, Drechsel P. Improving wastewater use in agriculture: An emerging priority. Policy research working paper 5412. The world bank water anchor energy, Transport, and Water Department; 2010.
3. Chen Z, Li JS, Poon CS, Jiang WH, Ma ZH, Chen X, Lu JX, Dong HX. Physicochemical and pozzolanic properties of municipal solid waste incineration fly ash with different pretreatments. Waste Management. 2023;160:146-55.
4. Li S, Skelly S. Physicochemical properties and applications of biochars derived from municipal solid waste: A review. Environmental Advances. 2023; 100395.
5. Unnisa SA, Rao BB, Vattikoti P. Biochemical parameters of selected plants as air pollution indicators. Acta Botanica Plantae. 2022;43-50.
6. UNDP. Urban Agriculture: Food, jobs and sustainable cities. UNDP publication series for Habitat II, Volume One. New York: UNDP; 1996.
7. Niranjana C. Characterization of bacteriocin from lactic acid bacteria and its antibacterial activity against Ralstonia solanacearum causing tomato wilt. Plant Science Archives; 2016.
8. Milad SMAB. Antimycotic Sensitivity of Fungi Isolated from Patients with Allergic Bronchopulmonary Aspergillosis (ABPA). In Acta Biology Forum. 2022;01(02):10-13.
9. Ashokri HAA, Abuzririq MAK. The impact of environmental awareness on personal carbon footprint values of biology department students, Faculty of Science,

El-Mergib University, Al-Khums, Libya. In Acta Biology Forum. 2023;02(02)18-22.

10. Augustine AU, Ioryue, IS, Wuana RA, Seasonal variation in waterquality parameters of river Mkomon Kwande local government area, Nigeria. International of Recent Research in Physical and Chemical Science. 2018;5(1):42-62.
11. Islam MS, Rahman MM, Paul NK. Arsenicinduced morphological variations and the role of phosphorus in alleviating arsenic toxicity in rice (*Oryza sativa* L.). Plant Science Archives. 2016;1(1):1-10.
12. BIS. Analysis of water and waste water. Bureau of Indian Standards, New Delhi; 1992.
13. Kavitha BS. Polisgowdar, Rubeena tarranum. Characterization of surface water and ground water reservoirs. Int. J. Curr. Microbiol. App. Sci. 2020;9(6):4070-4079.
14. Karthick S, Anand S, Srinivasan A, Jawahar P. Assessment seasonal variations in water quality parameters of Kadamba tank in Thoothukudi district of Tamil Nadu, India. International Journal of Applied Research. 2016;2 (11):329-334.
15. World Bank. Project appraisal document: Tehran sewerage project. Report No. 20154 IRN. Washington, DC: World Bank; 2000.

APPENDIX

A1. Technical specification of BOD incubator

Sl. No	Parameter	Specifications
1	Type	Cooling type, close control of incubation Storage temperature
2	Working chamber	Inside illumination with CFL
3	Construction	Double walled
4	Inner side	Made of stainless steel
5	Outer side	Made of milled steel
6	Refrigeration	CFC free
7	Temperature range	5°C to 60 °C
8	Accuracy	± 0.5 °C
9	No of BOD bottles	10
10	Capacity of BOD bottle	600 mi each

A2. Technical specifications of Digital Nephelo/Turbidity meter

Sl. No	Parameter	Specifications
1	Accuracy	±3% FSD in 0-1 and 0-1000 NTU ±2% FSD in 0-10 and 0-100 NTU
2	Readout	3 ½ digit LED
3	Range	0 -1 NTU, 0-10 NTU, 0-100 NTU, 0-1000 NTU
4	Mode of measurement	Direct
5	Model No.	132
6	Power	230 Volts ±10%, 50 Hz
7	Source	Projector lamp
8	Calibration	Formazine standard solution
9	Repeatability	±2% of FS (Std.)
10	Detector	Photodiode
11	Dimensions	265(W)×300(D)×170(H) mm
12	Weight	3.5 Kg (Approximate)

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/113966