

STATISTICAL ANALYSIS OF WASTEWATER AT PANJAPUR, TRICHY

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Abstract

This study is carried out to find wastewater quality index in treated wastewater, and Statistical analysis was done in various collected samples in sewage treatment plant, Panjappur, Trichy. This study presents a Statistical analysis of the physicochemical parameters of sewage wastewater. Nearly twenty parameters of two different months were analysed using data from physico-chemical analyses. A Continuous Waste Water Quality Index (CWWQI) was established to gauge the overall state of treated wastewater quality. By taking into account previously set quality limitation norms, the index condenses a substantial number of measured quality characteristics into a single water quality term. To identify treatment process performance, the interdependencies between the variables were determined by using Principal Component Analysis (PCA). This study presents Factor analysis to identify the pollution and its type. The methods and approaches discussed in this study offer a framework for evaluating the monitoring programme for wastewater treatment.

Keywords:

Waste water quality index;
Statistical analysis;
Factor analysis;
PCA principal component analysis;
Correlation matrix.

1 Introduction

Water that has been released into the environment is referred to as wastewater and is made up of water as well as wastes that have been added to the water from a variety of uses, including industrial, commercial, and residential ones. There are two sources that release wastewater into the environment. The process of eliminating toxins from wastewater, typically from domestic sewage, is known as sewage treatment [1]. To eliminate these impurities and create treated wastewater that is safer for the environment, it uses physical, chemical, and biological processes (or treated effluent). Sewage sludge is a common by-product of sewage treatment that typically requires additional processing before it is appropriate for disposal [2]. Municipal sewage wastewater is created by industrial processes and is also organic in content. It is discharged from domestic locations such as institutions, residences, and other similar settings. Wastewater treatment is the process that cleans the wastewater so that it may be disposed of back into a watercourse, and it is necessary to prevent these damages from occurring because these pollutions can be harmful to the environment and human health. To purify wastewater and safeguard the environment and the general public's health, wastewater treatment includes chemical, physical, and biological processes [3]. In some infrastructure facilities known as wastewater treatment plants, wastewater treatment takes place. The mechanical treatment, biological treatment, and sludge treatment components make up the majority of wastewater treatment plants. Diverse contaminants and wastes, including nutrients, inorganic salts, pathogens, coarse particles, etc., are present in wastewater and are particularly hazardous to both humans and the environment [4].

Various procedures have been exposed to eliminate these contaminants. In wastewater treatment, there are distinct chemical, physical, and biological processes and unit operations [5]. Prior to designing an effective wastewater treatment facility that takes into account the properties of the

wastewater, all these procedures should be taken into account. According to the properties of the wastewater, a wastewater treatment facility will be designed).

Wastewater produced by a community of people is known as sewage. The sewage system's design determines whether it also contains surface runoff and by a variety of means, all sewage ultimately returns to the environment where its constituent parts originated [6]. It entails bringing the discharged water's total nitrogen and phosphorus levels under a predetermined limit. To accomplish this, water may pass through bacterial treatment ponds once or more, alternately under aerobic and anaerobic conditions, depending on the plants and the intended outcome. Coagulation, flocculation, sedimentation – elimination of turbidity and colloid substances. Filtration – mechanical filters to remove rough particles, sand filters.

Whether it receives sewage treatment along the way to lessen its environmental impact is a fundamental difference in its journey [7]. Typically, sewage leaves a building's plumbing either into a sewer, where it will be transported elsewhere, or into one of the various onsite sewage facilities. Depending on the sewer design sanitary sewer or combined sewer it may be blended with surface runoff in the sewer. Sewers often discharged into a body of water such a river, lake, bay, stream, or ocean. The ecology was left to break down the human waste because there was no treatment.

Nowadays, it is preferred that sewers send their contents to a wastewater treatment facility rather than a body of water. This is the standard in many places, albeit it may still be a long way off in many developing nations [8]. In order to prevent environmental deterioration and attain sustainability, humanity is generally striving to become smarter about the sewage's course on its return back to the environment as the years and centuries pass. A legal need in an urbanised, industrialised culture is the proper collection and safe, annoyance-free disposal of a community's liquid wastes. The majority of wastewater produced globally does not get cleaned, which leads to widespread water pollution, especially in low-income nations.

Discriminate Analysis (DA), Principal Component Analysis (PCA), and Cluster Analysis (CA) techniques were used in a multivariate analysis of the wastewater quality.

2 Materials and methods

2.1 Study area

Panjappur sewage treatment facility was in Tiruchirappalli. One of Tamil Nadu's largest cities, Tiruchirappalli, commonly referred to as Trichy, is a significant hub for trade, education, and religious pilgrimage. According to the 2011 Census, the city has 916,857 residents. Compared to the state average of 515 people per square kilometre, the city's population density of 5,483 people per square kilometre is quite high. There are 228,518 people living in slums overall, or 26 % of the population [9]. The present study's municipal boundaries have been determined. It covers 159 square kilometres of land. The National Urban Sanitation Policy was published by the Ministry of Urban Development (MoUD) (NUSP). In order to achieve open defecation-free cities, create citywide sanitation plans, and provide 100 % safe containment, transport, treatment, and disposal of human excreta and liquid wastes, the policy seeks to: increase awareness; encourage behaviour change; achieve open defecation-free cities; do all of these things. The town has a total size of 67.87 square kilometres. Nine zones make up the town. Through a network of street sewers, the sewage produced by each zone is gathered and transported to the pumping station in that zone. The sewage collected in each zone is pumped to a sewage treatment facility built in the village of Panjappur using the waste stabilisation pond technique. The treated wastewater is discharged into a nearby natural channel and used for agriculture.

2.2 Collection and analysis of the sample

The waste water quality index was calculated using samples that were taken at various locations. To measure the variation month-to-month, samples were collected in January (winter) and may (summer). Following the physiochemical examination, the kind of contamination and the waste water quality index are determined.

Statistical Techniques in domains like geochemistry, hydrochemistry, mineralogy, and others, multivariate analyses were frequently used, mostly on geographical data [10]. The requirement to gather significant data reduction for analysis and decision making has led to a rise in water quality monitoring and evaluation over the past ten years.

Discriminate Analysis (DA), Principal Component Analysis (PCA), and Cluster Analysis (CA) techniques were used in a multivariate analysis of the wastewater quality.

From the three methods, here I selected Principal Component Analysis (PCA) adopted to found waste water quality Index and it is explained briefly below.

Discriminant analysis (DA) was used to find the seasonal variations in the data matrix, and the standard mode DA explained 66.6 % of total variance by grouping the cases with respect to seasons.

Cluster Analysis is used to reduce large number of monitoring sites into small homogeneous groups.

Principal Component Analysis (PCA) the principal components, which were linear combinations of the original variables, were created through PCA by transforming the original data into new, uncorrelated variables.

The classification of the pollutants' concentrations as weak, medium, or strong in the wastewater discharges from industry that are received in the treatment plant is a challenge for wastewater treatment systems. In order to help the operators of these systems make control decisions, a statistical analysis of the concentration of pollutants in the influent can be performed.

The concentration data in the influent from an outside source was taken into consideration during statistical analysis in a treatment plant. The parameters chemical oxygen demand and biochemical oxygen demand were also examined from the 10 parameters.

The findings showed that Wastewater was categorised as middle-class and that some wastewater discharges could be located. Statistical programme for Social Science and MS Excel were used to conduct the statistical analysis (SPSS version 14). The natural correlations between the waste water quality metrics were identified from this Principal Component Analysis. Principal Component Analysis (PCA) the principal components, which were linear combinations of the original variables, were created through PCA by transforming the original data into new, uncorrelated variables [11]. The new axes follow the directions of greatest variance. The PCA offered a method for discovering indices of this type that was impartial. PCA gave data on the most significant parameters that described the entire data set and attended data reduction; the minimum 10 was of original information. The principal component (PC) could be written as:

$$Z_{ij} = a_{i1}x_{1j} + a_{i2}x_{2j} + \dots + a_{im}x_{mj} \quad (1)$$

where:

Z - represented the component score,

X - the component loading, j the sample number,

M - the total number of variables, and X the measured value of the variable.

In an effort to explain the correlations between the observations in terms of underlying elements that were not immediately evident, factor analysis was used [12]. There are several steps to factor analysis, including. Wastewater Quality Index (WWQI) by taking into account all monitored quality indices cumulatively, the Wastewater Quality Index (WWQI) is a useful tool for expressing the overall state of wastewater.

$$F_1 = \frac{\text{Number of failed parameters}}{\text{Total of number parameter}} \times 100 \quad (2)$$

$$F_2 = \frac{\text{Number of failed parameters}}{\text{Total of number parameter}} \times 100 \quad (3)$$

$$\text{Excursion} = \frac{\text{Failed test values}}{\text{Limitation}} - 1 \quad (4)$$

$$Nes = \frac{\sum_j^n \text{Excursion}}{\text{Number of test}} - 1 \quad (5)$$

$$F_3 = \frac{Nes}{0.01 nes + 0.01} - 1 \quad (6)$$

$$WWQI = 100 - \frac{\sqrt{F_1 + F_2 + F_3}}{1.732} \quad (7)$$

3 Result and discussion

For winter and Monsoon season, In January and May month totally ten samples are taken in different locations in the discharge area. The parameters tested are pH, color, TSS, DO, BOD, COD, Chloride, sulphate, phosphate, Ammonia, Nitrate, Total phosphate and temperature are characterized. For Summer and Spring season, In June and November month totally ten samples are taken in different locations in the discharge area. The parameters tested are pH, color, TSS, DO, BOD, COD, Chloride, sulphate, phosphate, Ammonia, Nitrate, Total phosphate and temperature are characterized.

Table 1: Type of pollution based on components (Jan).

	Component 1	Component 2	Component 3
PARAMTERS	TSS	pH	Alkalinity
	Ammonia	Chloride	BOD
	Nitrate	Nitrite	SO ₄
	Phosphate	Sulphate	COD
	Chloride	TDS	pH
TYPE OF POLLUTION	Organic /Biological pollution	Domestic wastewater pollution	Agricultural pollution
% OF POLLUTION	22.907 %	13.14 %	12.279 %
Total - 48.33 %			

Table 2: Type of pollution based on components (May).

	Component 1	Component 2	Component 3
PARAMTERS	TSS	pH	Alkalinity
	Ammonia	Chloride	BOD
	Nitrate	Nitrite	SO ₄
	Phosphate	Sulphate	COD
	Chloride	TDS	Ph
TYPE OF POLLUTION	Organic /Biological pollution	Domestic wastewater pollution	Agricultural pollution
% OF POLLUTION	26.90 %	11.14 %	15.27 %
Total - 53.33 %			

Table 3: Type of pollution based on components (June).

	Component 1	Component 2	Component 3
PARAMTERS	TSS	pH	Alkalinity
	Ammonia	Chloride	BOD
	Nitrate	Nitrite	SO ₄
	Phosphate	Sulphate	COD
	Chloride	TDS	pH
TYPE OF POLLUTION	Organic /Biological pollution	Domestic wastewater pollution	Agricultural pollution
% OF POLLUTION	27.07 %	14.14 %	13.9 %
Total - 55.11 %			

Table 4: Type of pollution based on components (November).

	Component 1	Component 2	Component 3
PARAMTERS	TSS	pH	Alkalinity
	Ammonia	Chloride	BOD
	Nitrate	Nitrite	SO ₄
	Phosphate	Sulphate	COD
	Chloride	TDS	pH
TYPE OF POLLUTION	Organic /Biological pollution	Domestic wastewater pollution	Agricultural pollution
% OF POLLUTION	29.00 %	17.15 %	14.32 %
Total - 60.47 %			

In the statistical method Principal component analysis generates three principle components for the samples and explaining 48.33 % of the total variance.

3.1 Principal component analysis

Three principal components are produced via principle component analysis for the samples, accounting for 48.33 % of the total variance [14]. The first factor accounts for 22.907 % of the total variance. This factor displays high positive factor loading for ammonia, nitrite and phosphate. In this group pollution is influenced by domestic matters. The second factors represent 13.147 % of the total variance. The factors provide information about pH, chlorides, nitrate and sulphate [15]. This loading symbolizes domestic water discharge and the last component shows 12.27 % of total variance.

Principal component analysis (PCA) is intended to change the original variables into principal components, which are linear combinations of the original variables and are new, uncorrelated variables [16]. The percentage of each component are obtained that shows component 1 has contributed about 22.907 % of pollution to overall pollution component 2 has contributed about 13.14 % of pollution and component has contributed about 12.279 % of pollution to overall pollution.

Three principle components are produced by principal component analysis for the samples, accounting for 53.33 percent of the total variance (May month). The first factor is responsible for 26.907 % of the variance overall. The second factors represent 11.14 % of the total variance. The factors provide information about pH, chlorides, nitrate and sulphate [17]. This loading symbolizes domestic water discharge and the last component shows 15.27 % of total variance. The percentage of each component are obtained that shows component 1 has contributed about 26.9 % of pollution to overall pollution component 2 has contributed about 11.14 % of pollution and component has contributed about 15.27 % of pollution to overall pollution [18] and other two months having higher values.

4 Wastewater Quality Index (WWQI)

To keep treated water of a high standard, wastewater treatment facilities must run effectively. Utilizing the Wastewater Quality Index (WWQI) and statistical methods, the current study's objective is to monitor the effluent quality. The influent and effluent wastewater samples were taken from Panjappur Trichy, Tamil Nadu, India, Effluent Treatment Plant (ETP).

The biodegradable and non-biodegradable pollutants in the wastewater were identified through an analysis of the physicochemical properties. Using criteria, WWQI assessed the overall quality of the wastewater.

For samples, the wastewater quality index was used. Table 3 displays the wastewater quality index classification [19]. It demonstrates that the range from 0 to 44 is really poor, 45 to 64 is marginal, 65 to 79 is decent, 80 to 94 is good, and 95 to 100 are excellent.

Table 3: Classifications of wastewater quality range.

Range	Type of water
95-100	Excellent
80-94	Good
65-79	Fair
45-64	Margin
0-44	Very poor

The WWQI ranges for each sample taken in the study region are displayed in the table below. Approximately 2 samples are fair, 14 samples are in the margin of error, 2 samples are poor, and 4 samples are really poor, according to the table. We can therefore conclude from the entire sample that the summer season has a wider overall margin value range than the winter season [20].

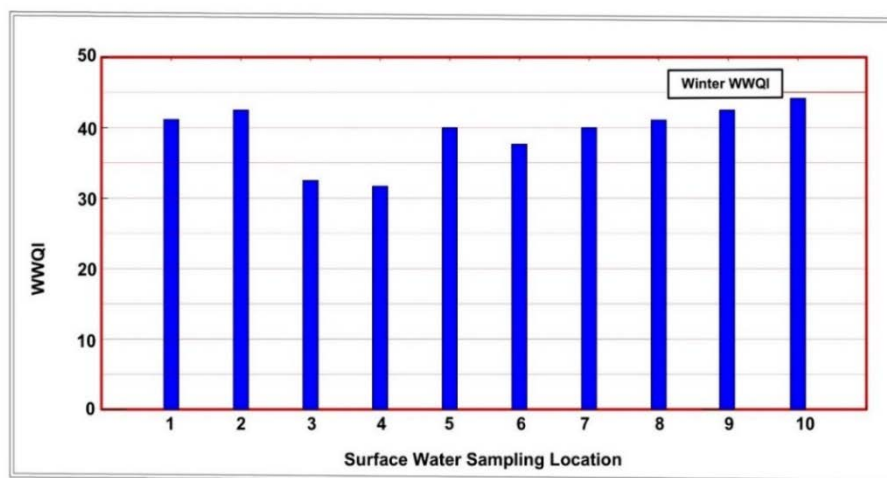


Fig. 1: Winter Waste Water Quality Index (January).

The wastewater quality index (WWQI) is an efficient mechanism to express the overall condition of wastewater by cumulative consideration of all monitored quality indices. The graph shows the ranges of the sample according to their WWQI for the month of January and May. So, from the graph we can identify that the summer season has a wider overall margin value range than the winter season [21].

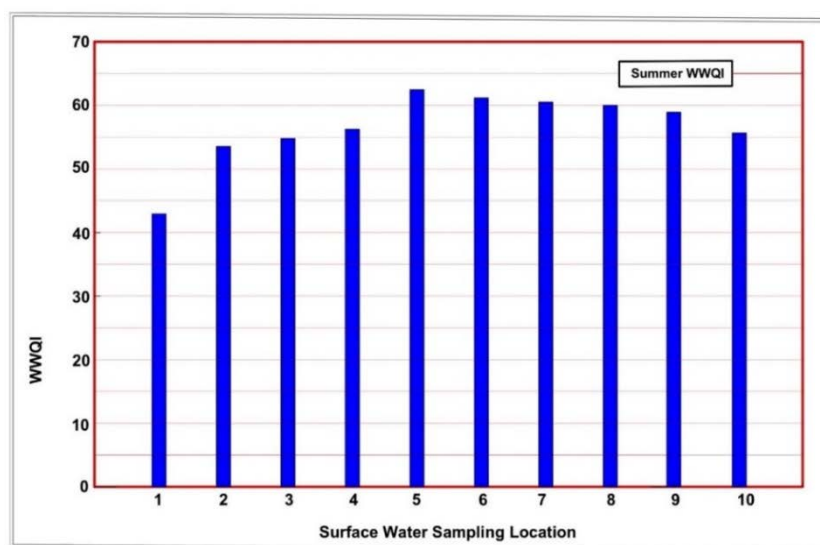


Fig. 2: Winter Waste Water Quality Index (May).

Table 4: Wastewater quality index in study area.

Samples	WWQI	Classification
W1	42.1	Poor
W2	43.9	Poor
W3	33.6	Very poor
W4	32.6	Very Poor
W5	49.8	Margin
W6	57.8	Margin
W7	39.9	Very poor
W8	40.8	Very poor
W9	61.8	Margin
W10	65.7	Fair
S1	45.9	Margin
S2	55.9	Margin
S3	56.2	Margin
S4	57.4	Margin
S5	65.9	Fair
S6	62.9	Margin
S7	61.5	Margin
S8	60.6	Margin
S9	59.8	Margin
S10	55.9	Margin
M1	56.2	Margin
M2	62.6	Margin
M3	65.4	Margin
M4	45.5	Margin
M5	51.6	Fair
M6	67.8	Fair
M7	53.5	Margin
M8	62.9	Margin
M9	71.2	Fair
M10	80.2	Good
A1	33.5	Very poor
A2	39.5	Very poor
A3	49.5	Margin
A4	52.7	Margin
A5	62.7	Margin
A6	72.6	Fair
A7	79.2	Good
A8	84.5	Good
A9	86.9	Good
A10	87.2	Good

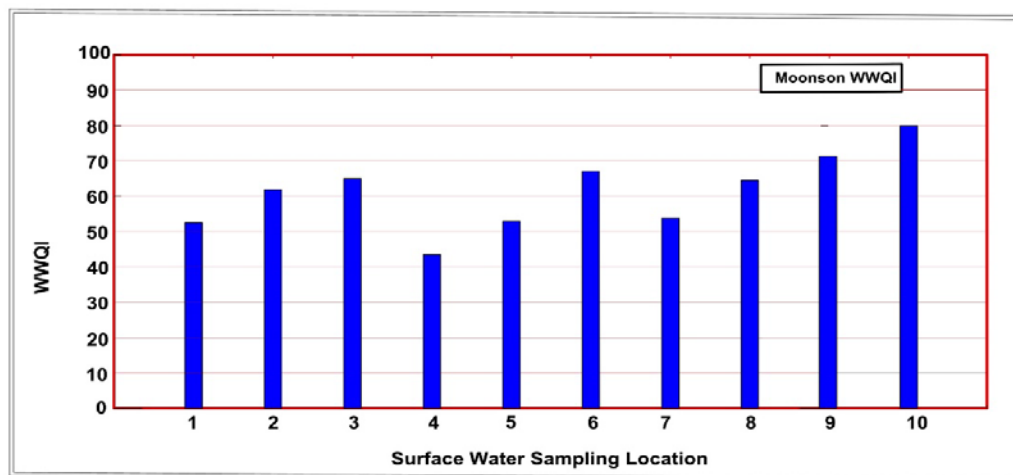


Fig. 3: Monsoon Waste Water Quality Index (August).

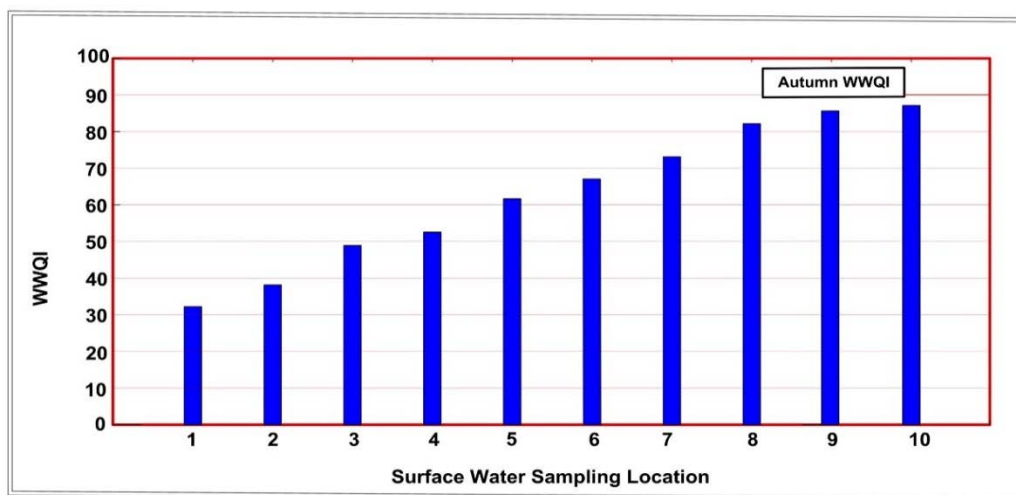


Fig. 4: Autumn Waste Water Quality Index (November).

5 Conclusion

This study gives a complete assessment of wastewater in the selected treatment plant in all aspects. The results of wastewater quality index, statistical method provides an outright of the water quality.

5.1 Statistical method

From the studies, it can be concluded that the wastewater quality in certain places of treatment plant, suitable for domestic and industrial purpose. Some parameter like pH, Nitrate and some parameters are not within the acceptable limit [22]. In certain case the pollution is high in some selected locations. It is found that the wastewater quality of treatment plant is poor in some specific areas and not fit for domestic purposes. This study also analyses the type of pollutants that influences the provide more treatment methods to improve the treatment to reduce the pollution [23].

5.2 Wastewater Quality Index (WWQI)

For the wastewater quality index analysis, ten wastewater sample was taken were it found highly polluted among the study area. From this analysis, the treated wastewater was classified as 31.25 % of samples were in margin 37.5 % of samples were in poor 25 % of sample were in very poor. Because accumulated pollutant that causes problem. From the result it is concluded that 25 % of water are not with in limit which is unfit for any purpose.

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