Physico-Chemical Assessment of Water Quality in One Part of Hinjewadi, Pune, Maharashtra, India

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Abstract

The present study was aimed at assessing the Physico-chemical parameters viz., temperature, Electrical Conductivity (EC), pH, turbidity, Total Alkalinity (TA), Total Hardness (TH), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Chloride, Potassium, Zinc, Copper, Total Iron, BOD, COD, Oil, and Grease at in Alard College Campus, situated in Hinjewadi, Pune. The aim of the work under the title is to analyze the College Campus water outlet, by dividing it into various sampling station. Water quality in the study area was found to have high value of pH, EC, TDS. A systematic correlation in this study showed that there was a significant linear relationship among different pairs of water quality parameters. It was concluded that the TDS, EC and pH are important physicochemical parameters of water quality and are correlated with most of the other parameters. The present study also identifies the critical pollutants affecting the campus water quality.

Keywords: Physico-chemical parameters; Systematic correlation; Water pollutant; pH; EC; TDS

Introduction

Providing clean and safe water is the major challenge with the increasing industrialization and globalization. Public health and life of the people are greatly influenced and endangered by water contamination. Prehistoric civilizations (e.g., Mesopotamian, Indus valley, and Minoan) from the Bronze Age (ca. 3200-1100 BC) used the domestic waste water for irrigation and other purpose. It was also scripted in Hellenic civilizations and later by Romans that waste water can be used for irrigation, and fertilization purposes (e.g., Athens and Rome) [1]. Modernization and industrialization in cities influence the quality of water directly or indirectly [2,3]. The growth of industries, increasing population and developmental activities are changing rural areas into urban which lead to water scarcity, climate change, and different kind of pollution of water resources [4-6]. Prolonged discharge of industrial effluents, domestic sewage and solid waste dump pollute the groundwater causing health problems [7].

Analysis of water and waste water is necessary right from the planning stage of any water purification and waste water treatment projects. This is important because only the analysis of the raw water from the source or the waste water coming out of the community can tell the correct initial characteristics of water and waste water on which depends on which depends the proper and economical solution to the problem of treatment. Pune city is developing many folds as more and more people from outside cities are migrating during the last 2-3 decades which triggered water pollution in many parts of the city.

To cater large population only one sewage treatment plant is present in Pune city which has a capacity of 90 MLD (million liters per day). The plant only treats 50-55% of the water and remaining untreated effluents are usually discharged into rivers directly [8].

IT companies in the city make Hinjewadi as one of the hot localities of Pune. Hinjewadi can be divided into two parts: one is the MIDC (Maharashtra Industrial Development Corporation) area which is further divided into many phases and rest of the part of Hinjewadi village areas surrounding MIDC. The village areas are again divided into seven phases out of which three phases are developing fast and lot of renowned developers are constructing integrated townships. The other village areas like Marunji, Gotavari, Nerhe and Dattwadi are poorly developed with only local population or independent sites. People working in IT companies prefer to live near their official location. Preferred location leads to increased water demand as well its utilization both in the integrated townships and independent projects (Figure 1).

This research paper is divided into two parts. In the first part, we are going to analysis physico-chemical and in the second part statistical analysis of the parameters of waste water in Alard college campus coming from hostel washing area, bathrooms, kitchen, etc. We are treating the water by the standard procedure. To the best of our knowledge, no such study has been carried out in this region.

Clean water is the scarce commodity. It should be conserved and reused. The waste water not necessarily contains only pollutants but sometimes contains elements like phosphorus and nitrogen which could be recovered and utilized as fertilizers for crop growth. This approach is profitable for sustainable future. But often waste water cannot be used without treatment. Treatment of waste water can be carried out first by preliminary treatment followed by secondary treatment and if necessary advanced or tertiary treatment.

The major goal of the primary treatment is to remove those pollutants from waste water that will either settle down or float. Primary treatment typically removes 60% of the suspended solids in raw sewage and 35% BOD. Secondary treatment removes 85% BOD, suspended solids, nitrogen phosphorus and heavy metals etc. Untreated water produces foul odors because of biological decomposition of organics. Many water borne diseases can be eliminated by waste water treatment.

The essential purpose of water analysis is to determine the fitness...
or potential fitness of the water, for the use it is put to in house or industry. Similarly, the essential purpose of sewage analysis is to find the concentration and condition of the sewage or effluent from the treatment plant and the effect or potential effect of its discharge into receiving body of water or into land.

We attribute water as safe or unsafe, pure or impure, palatable or unpalatable hard or soft, corrosive or non-corrosive, sweet or saline as the case may be. Similarly of sewage or sewage effluents we say putrescible or non-putrescible, strong, or weak, fresh or stale or septic.

Waste water has historically been considered a nuisance to be discarded in the cheapest, least offensive manner possible. This meant the use of on-site disposal systems such as the pit privy and direct disposal is restricted. Because the number of chemical compounds found in wastewater is almost limitless, we normally restrict our consideration to a few general classes of compounds.

All the types of the physical parameters are performed on site by direct appearance. The physical test is such as temperature, color, odour, pH, Turbidity, TDS etc, and chemical test are BOD, COD, dissolved oxygen, alkalinity, hardness and other characters.

Clean water is a rare commodity; it should be treated as such and conserved and reused. For traces metal, heavy metal contents and organic i.e., pesticide residue are also tested to obtained perfect picture of the purity of water.

Heavy metal and organic pesticides impurities are determined by the highly sophisticated analytical instruments and with trained staffs. Different physic chemical parameters are tested regularly for monitoring quality of water.

The physic-chemical analysis of water has been done in three seasons, samples were collected for three seasons i.e., Pre-Monsoon, Monsoon and Post-Monsoon. The samples were collected in sterilized bottles using standard procedure.

The Main Objectives of the Present Study are:

- Protect the aquatic life from the toxicity of waste
- To make the waste water usable for agricultural, washing floors, flushing etc.
- Evaluating the strength of a waste by studying the primary sources of water and mapping BMC pipeline.
- Estimating the maximum amount of pollutant that a water body can receive and still meet water quality standards.
- To identify the sources of pollution in water supply and its distribution.
- To understand the financial aspects of dealing with water supply network in the campus.
- Try to find out the water subsidy, if any, provided to the campus residents.

The implementation of the highlighted studies can be done in following steps:

- Collection of ground water samples from bore wells, hand pumps, surface water from Alard college campus at different sites before Monsoon during the months of May and June.
- Analysis of a few water quality parameters viz., pH, temperature, EC, turbidity, TDS, TA, TH, DO, concentrations of calcium, magnesium, chloride, nitrate, fluoride and phosphate.
- Comparison of the analyzed data with standard values recommended by World Health Organization (WHO 1997).
Correlation coefficient and linear regression

The simple linear correlation analysis has been carried out to find out the correlation between two tested parameters. To find the relationship between two parameters x and y, the Karl Pearson's correlation coefficient, r, is used. It was calculated using following equation:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

Where, N=number of data points; X=values of x-variable; Y=values of y-variable.

Materials and Methods

Proper sampling and analytical techniques are of fundamental importance in the characterization of waste water. All the chemicals are analytical Analar grade were used. Chemicals are prepared in deionized water.

Sampling

Alard college campus water coming through the hostel from washing area, bath, kitchen etc., those have created unhygienic condition. After sampling all the glassware’s which we are going to use during the analysis should be triplicate clean, first with detergent then by 25% nitric acid and finally rinsed with de ionized water. The pH and conductivity, were determined in site location and for feather analysis it should be stored at a temperature below 4°C, which protect the sample from organic growth.

All the parameters were analyzed by using standard methods [9-11] (Table 1). Different parameters are analyzed, and procedure employed for measuring these parameters are given in the Table 2. Result of these parameters is given in the Table 3, and compared with standard values recommended by World Health Organization (WHO 1997) and IS standards.

Correlation coefficient and for pairs of parameters having significant values

**pH:** pH is one of the most important and useful tests in the control of water quality. Many chemical and biochemical reactions take place at certain pH value. Control of pH is particularly important in the chemical coagulation or water, softening and disinfection of water supplies by chlorine etc.

The pH value of water samples, in lab changes because of lesser absorption of gases, reactions with sediments, chemical reaction taking place within the sample bottle. Therefore, pH value should preferably be determined at the time of collection of sample.

PH values are generally determined electrometrically or calorimetrically. The electrometric method is more accurate but requires special apparatus. The calorimetric method is simple and requires less expensive apparatus, and is sufficiently accurate for general work.

The hydrogen ion concentration is an important quality parameter of both natural waters and waste waters. The usual means of expressing the hydrogen ion concentration is as pH, which is defined as the negative logarithm of the hydrogen ion concentration. The concentration range suitable for the existence of most biological life is quite narrow and critical (typically 6 to 9). PH of samples of Alard College of Engineering and Management lies in between 7 to 7.54 which are within the limit prescribed by WHO. PH show strong correlation with electrical conductance and total alkalinity [12] (Graph 1).

**Turbidity:** In most of the water samples, the turbidity values varied between 10-120 NTU. Turbidity was due to colloidal and extremely fine dispersions and was found above the limits prescribed by WHO. The intensity of light scattered by the sample under defined conditions is compared with the intensity of light scattered by a standard reference suspension under the same conditions, forms the basis of determination of turbidity. Higher the intensity of scattered lights higher the value of turbidity.

Turbidity is not so much a health concern as an indicator of health risk. Science has proven that as turbidity increases, the risk to human health also increases-particularly for at-risk populations such as newborns, the elderly, and people compromise with weak immune systems (e.g., those with HIV/Aids, undergoing chemotherapy, or taking anti-rejection drugs) (Graph 2).

**Electrical Conductivity (EC):** EC values for all the investigated samples were found to be in the range 300-490 µS/cm. These were greater than the limits prescribed by WHO (300 µS/cm).

Conductivity shows strong correlation with eight parameters of physio-chemical analysis of water these are (1) temperature, as the temperature increase the conductivity of water increases, (2) pH value, (3) alkalinity (4) hardness total solids, (5) total dissolved solids, (6) chemical oxygen demand (7) chloride and (8) iron concentration of water [13]. All the parameters show deflection in detected value when there are increase or decrease with conductivity.

EC values indicate salt content is evaluated in water [14]. Water purity is evaluated by Electrical conductivity [15] (Graph 3).

**Chloride:** Chloride content of the water samples were found to be in the range 3.5 to 120 mg/L. All the values were within the prescribed limit. Water additive used to control microbes, disinfec, but no such purification process is performed yet. The water coming from the hostel, canteen, washing area was poured as such. No treatment process is performed yet. The water coming from the clothes washing area was found above the limit prescribed by WHO, as newborns, the elderly, and people compromise with weak immune systems (e.g., those with HIV/Aids, undergoing chemotherapy, or taking anti-rejection drugs).

**Oil and grease:** Pen Reflux Method is used for the measurement of various components of water samples.
### Table 2: The values of physico-chemical parameters of ACEM water during May-June 2016.

| S. No. | Parameters          | S1   | S2   | S3   | S4   | WHO 1997 | ISO10500-91 |
|-------|---------------------|------|------|------|------|----------|-------------|
| 1     | pH                  | 7.8  | 7.9  | 7.8  | 8.01 | 6.5-8.5  | 6.5-8.5     |
| 2     | Temperature         | 25.2 | 25.2 | 25   | 25   | -        | -           |
| 3     | EC, µm/cm           | 490  | 490  | 426  | 300  | 300      | -           |
| 4     | Turbidity, NTU      | 10   | 40   | 60   | 120  | 5        | 10          |
| 5     | TDS, mg/L           | 386  | 386  | 390  | 258  | 600      | 500         |
| 6     | Alkalinity mg/L     | 15   | 20   | 30   | 80   | -        | 200 ppm     |
| 7     | Total Iron mg/L     | 0    | 1    | 2    | 3    | 6        | 5           |
| 8     | DO, mg/L            | 3.3  | 6    | 5.8  | 5    | 6        | 5           |
| 9     | Zinc, mg/L          | 0.1  | 0.1  | 1    | 2    | 6        | 5           |
| 10    | Copper, mg/L        | 0    | 0    | 0.2  | 0.2  | 6        | 30          |
| 11    | Chloride, mg/L      | 3.5  | 60   | 50   | 120  | 25 ppm   | 250 ppm     |
| 12    | Potassium, mg/L     | 3.5  | 60   | 50   | 120  | 25 ppm   | 250 ppm     |
| 13    | B.O.D (mg L⁻¹)      | 18   | 18   | 19   | 18   | 6        | 30          |
| 14    | C.O.D. (mg L⁻¹)     | 48   | 43   | 45   | 50   | 10       | -           |
| 15    | Oil and Grease      | nil  | nil  | nil  | nil  | nil      |             |

### Table 3: Linear regression equation.

| Sr. No | Pairs of parameters | R²       | Regression coefficient | Regression equation |
|--------|---------------------|----------|------------------------|---------------------|
| 1      | EC and TDS          | 0.9313   | 0.672                  | TDS=0.672(EC)+68.09  |
| 2      | Turbidity and Alkalinity | 0.9653 | 0.619                  | Alkalinity=0.619(Turbidity)+0.617 |
| 3      | Alkalinity and Total Iron | 0.9484 | 0.03                   | Total Iron=0.030(alkalinity)+0.646 |
| 4      | Total Iron and Zinc  | 0.9966   | 0.954                  | Zinc=0.954(Total Iron)+0.854 |
| 5      | Total Iron and copper | 0.9045 | 0.109                  | copper=0.109(Total Iron)-0.09 |
| 6      | Zinc and potassium  | 0.9898   | 1.815                  | Potassium=4.918(zinc)+1.815 |

### Table 4: Linear regression equation.

| pH     | Temperature | EC µm/cm | Turbidity, NTU | TDS, mg/L | Alkalinity mg/L | Total Iron mg/L | DO, mg/L | Zinc, mg/L | Copper, mg/L | Chloride, mg/L | Potassium, mg/L | B.O.D | C.O.D | Oil and Grease |
|--------|-------------|----------|----------------|-----------|-----------------|-----------------|----------|------------|--------------|----------------|-----------------|-------|-------|---------------|
| -0.3171| 1           | -0.7514  | 0.81864        | 0.81513   | -0.8078         | -0.9641         | 1        | -0.9717    | -0.9873      | -0.9854        | 0.95549         | 0.94843| 1     | -0.8861       |
| 0.64413| -0.7259     | -0.9873  | 0.96525        | -0.9717   | 1               | 0.65198         | -0.9045  | -0.9854    | 0.95873      | -0.8926        | 0.90453         | 0.42312| 0.89261| 0.31715       |
| 0.33133| -0.4231     | -0.2364  | 0.4743         | -0.0746   | 0.23671         | 0.33133         | -0.4231  | -0.2364    | -0.9896      | -0.8926        | 0.90453         | 0.42312| 0.89261| 0.31715       |
| 0.66912| -0.8926     | -0.9896  | 0.95873        | -0.8694   | 0.95649         | 0.66912         | -0.8926  | -0.9896    | -0.8926      | -0.8926        | 0.90453         | 0.42312| 0.89261| 0.31715       |
| 0.31715| -1          | -0.8186  | 0.80778        | -0.5333   | 0.7259          | 0.31715         | -1       | -0.8186    | -0.80778     | -0.80778       | 0.90453         | 0.42312| 0.89261| 0.31715       |
| 0.91085| -1          | -0.8682  | 0.96008        | -0.8522   | 0.90727         | 0.91085         | -1       | -0.8682    | -0.8682      | -0.8682        | 0.90453         | 0.42312| 0.89261| 0.31715       |
| 0.76756| -0.834      | -0.9953  | 0.98456        | -0.9148   | 0.98411         | 0.76756         | -0.834   | -0.9953    | -0.9953      | -0.9953        | 0.98456         | 0.98644| 0.83395| 0.9038        |
| -0.516 | -0.5774     | -0.0037  | 0.03587        | 0.36067   | -0.1397         | -0.516          | -0.5774  | -0.0037    | -0.0037      | 0.03587        | 0.36067         | 0.17408| 0.14724| 0.57735       |
| 0.51602| 0.57735     | 0.00372  | -0.3607        | 0.1397    | -0.1741         | 0.51602         | 0.57735  | 0.00372    | 0.3607        | 0.1397         | -0.1741         | -0.4006| -0.14724| 0.57735       |

### Table 4: Linear regression equation.

#### Alkalinity
The alkalinity values were found to be in the range of 15-80 mg/L. The alkalinity values below the values 120 and 200 mg/L prescribed by WHO and ISI respectively. Alkalinity is an important property of water. Its concentration determines the extent to which can be neutralized. Alkalinity is chiefly caused by bicarbonate, carbonates and hydroxide of alkali earth metal, Ca, Mg, K. It is expressed in terms of three forms they are Hydroxide, Carbonate, and Bicarbonate. Alkalinity value of water provides an estimate of dissolved mineral salts. Little abnormal value of alkalinity is not harmful to human beings, but it is important to determine the suitability of water for irrigation and/or mixing some pesticides. It also becomes important while interpreting and controlling water treatment process (Graph 5).

#### Dissolved Oxygen (DO): Dissolved oxygen values varied from 2.3
to 5.0 mg/L, well within the prescribed limit (4-6 mg/L). Dissolved is essential for aquatic life. Generally low DO (less than 2 mg/l) would indicate poor water quality and which creates difficulty in many aquatic lives. The DO values indicate the pollution level, more DO value, less the pollution. The imbalance in aquatic life is responsible for lowering the value of dissolved oxygen [17]. Less DO value produces foul smell.

It can also cause an increase in the concentration of ferrous iron in solution, with subsequent discoloration at the tap when the water is aerated (WHO 2008).

| Site Code | Turbidity | Alkalinity  |
|-----------|-----------|-------------|
| S1        | 10        | 10          |
| S2        | 40        | 13          |
| S3        | 60        | 19          |
| S4        | 120       | 50          |

Table 5: The predicted and observed values of alkalinity on the basis of turbidity.

| Site Code | EC  | TDS  |
|-----------|-----|------|
| S1        | 490 | 327  |
| S2        | 490 | 327  |
| S3        | 426 | 330  |
| S4        | 300 | 241  |

Table 6: The predicted and observed values of TDS on the basis of EC.
Dissolved oxygen is required for the respiration of aerobic as well as anaerobic microorganisms. Because the rate of biochemical reactions that use oxygen increases with increasing temperature, dissolved oxygen levels is critical during the summer season. The problem increased substantially in summer month because team flow is usually low (Graph 6).

DO in sample is measured titrimetrically by Winkler's method after 5 days incubation at 293 K. The apparatus used are:

- Incubation bottles
- DO meter
- Air incubator

**BOD:** The amount of oxygen required to oxidize substance to carbon dioxide and water may be calculated by stoichiometry if the chemical composition of the substance is known. The most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day BOD. This determination involves the measurement of the dissolved oxygen used by micro-organisms in the biochemical oxidation of organic matter. BOD values for water samples were found 18.0-19.0 mg/L. The permissible limit for drinking water is 30 mg/L. BOD values were observed within the limit for all the samples. All the values are determined using standard laboratory techniques; at a temperature of 20°C. The standard test condition lets in incubating the sample in an air tight bottle, in dark at a required temperature for specific time (Graph 7).

**Chemical Oxygen Demand (COD):** COD values of the analyzed water samples were found 48-50 mg/L. The permissible limit of COD for drinking water is 255 mg/L. The COD test is used to determine the oxygen equivalent of the organic matter that can be oxidized by strong chemical oxidizing agent (potassium dichromate) in an acid medium. The COD of a waste, in general, will be greater than the BOD because more compounds can be oxidized chemically than can be oxidized biologically. Both BOD and COD serve as a milestone for the environmental health of a surface water supply (Graph 8).

**Determination of metals**

The Atomic Absorption Spectrometer is used to determine the contents of metals in the waste water sample. The observed iron content was in the range of 0 to 3 mg/L. Zinc is 0.1 to 2 mg/L and Copper content range from 0 to 0.2 mg/L values for water samples. in the flame. For each metal there is one distinct absorption wavelength, so a source lamp formed of that element is used. This makes it free from spectral interference. The amount of energy of the characteristic wavelength absorbed in the flame is determines proportional to the concentration of the element in the sample.

A correlation matrix for different water quality variables is depicted in Table 4. The systematic calculation of correlation coefficient helps to find (r the predicted and observed values of TDS on the basis of EC and alkalinity on the basis of turbidity (Tables 5 and 6).

**Conclusion**

Increasing water pollution is a major problem in all the rivers. Contaminated water is the biggest health risk and continues to threaten both quality of life and public health. The analysis of the water quality parameters has been done at different location in Alard College campus Hinjewadi. The results were compared with the water quality standards of WHO and IS 10500-91. EC, PH and turbidity values for all investigated samples were found to be above the permissible limit. The result shows that the rest of the parameters like TDS, Alkalinity, Total Iron, DO Zinc, Copper, Chloride Potassium, BOD and COD values are lies within the permissible limits. The systematic calculation of correlation coefficient (r) between various physicochemical parameters has been done to compare the water quality level at different locations and to suggest priority for the required treatment to a particular location. A systematic correlation in this study showed the EC and turbidity are important physicochemical parameters of water quality and there was a significant linear relationship among different pairs of water quality parameters. It was concluded that EC shows strong correlation with turbidity, alkalinity, total hardness etc are significant physicochemical parameters of water quality and are correlated with most of the other parameters.

In conclusion from the results of the present study it may be said that the outlet water of the study location is not fit for domestic and drinking purpose and it need treatments to minimize the contamination. It indicates that the outlet water from Alard campus is highly polluted and unsafe for domestic use.

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