PHYSICO-CHEMICAL ASSESSMENT OF WATER QUALITY IN ONE PART OF HINJEWADI, PUNE MAHARASHTRA (INDIA)

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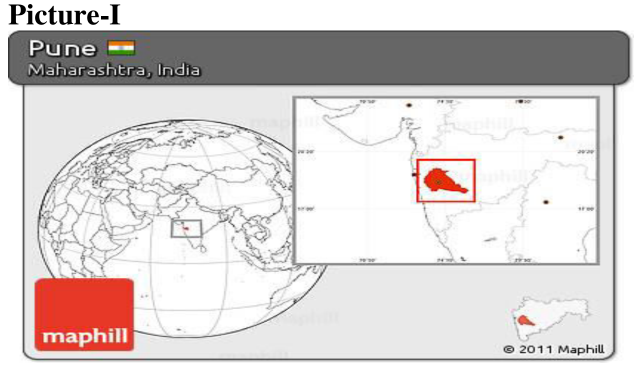
ABSTRACT
The present study was aimed at assessing the Physico-chemical parameters viz., temperature, electrical conductivity (EC), pH, turbidity, total alkalinity (TA), total hardness (TH), total dissolved solids (TDS), dissolved oxygen (DO); chloride, potassium, Zinc, Copper, total Iron, BOD, COD, oil 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.*

1. INTRODUCTION
Providing clean and safe water is the major challenges with the increasing industries pollution and globalization. Public health and life of the people are greatly influenced and endanger by the contaminated water. [2] Prehistoric civilizations (e.g., Mesopotamian, Indus [32] valley, and Minoan) from the Bronze Age (ca. 3200–1100 BC) the domestic Waste water are used 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) (Tanakakis V.E et al., 2007). Modernization and industrialization in cities influence the quality of water directly or indirectly (Van Leeuwen 2013, Wellen et al., 2015). With the growth of industries, increasing population and developmental activities changes rural areas into urban which leads to water scarcity , pollution and climate change result in different kind of pollution of water resources (Yadav et al., (2013, Singh and Jangde 2013, Sanders , 2015). Prolonged discharge of industrial effluents, domestic sewage and solid waste dump pollute the groundwater causing health problems (Panasiuk et al.,2015).
Analysis of water and waste water is necessary even at the planning stage of any water purification and waste water treatment projects, because on analysis of the raw water from the source or the waste water coming out of the community only can tell the correct initial characteristics of water and waste water on which depends the proper and initial stages of planning of water and waste water on which depends the proper and economical solution to the problem of treatment. Pune city is developing many folds more and more people from outside cities are migrating during the last 2-3 decades which trigger water pollution in parts of the city.

To cater large pollution only one sewage treatment plant is there in Pune city which has a capacity of 90 MLD (million liters per day).The plant only treat 50 -55% of the water and remaining untreated effluents are usually discharged into the rivers directly. IT company in the cities make

Picture-I



Hinjewadi is one of the hot localities of Pune. Hinjewadi can be[5]divided into two parts: one is the MIDC[5](Maharashtra Industrial Development Corporation)area which is further divided into many phases and rest of the part of Hinjewadi village areas surrounding MIDC. The villages area are again divided into seven phases. Out of which three phases are developing fast and lot of renowned developers as developed integrated townships. In opposite to the village areas like[5]Marunji, Gotavari, Nerhe and Dattwadi are poorly developed with only local poplution. or independent sites. People working in IT companies wanted to live near their official location. Preferred location leads to increasing water demand as well its utilization both in both the integrated townshipsand independent projects, Picture-I(D.G. Kanase et al,2014).

Picture-II

Alard College of Engineering and Management were established in 2009 is a premier technical and tactical training institution of the Engineering. Alard College of Engineering and[12]Management, is recognized by AICTE New Delhi and DTE, Government of Maharashtra, and is affiliated to Savitribai Phule Pune University The college offers Engineering, Pharmacy and management courses at the undergraduate and post graduate levels. The courses are offered majorly in various fields of engineering and technology, management and pharnacy. The undergraduate engineering programmes are offered in various disciplines which include Civil Engineering, Mechanical Engineering, Computer Science and Electrical and Electronics Engineering, Applied sciences. Alard Engineering college trust impart quality education, training and research activities, providing backbone for better future for Good Scientists, Technocrats, Administrators and Entrepreneurs with Social Awareness. They also inculcate Professional Ethics and Leadership Qualities. They provide board spectrum of Academic and Research Programs and strives to develop a world class centre of excellence for learning.

Picture-III

This research paper in divided into two parts in first part we are going to analysis physic-chemical and in the second part statistical analysis of the parameters of waste water in Alard college campus coming through the hostel from Washing area, bath, kitchen etc, those have create unhygienic condition. We are treating the water by the standard procedure. . To best of our knowledge no such study has been carried out in this region

The physicochemical parameters of water include: The wastewater continues to flow through the collection system and eventually reaches the wastewater treatment plant. Upon reaching the plant, the flow first encounters preliminary treatment. Preliminary treatment is followed by primary treatment, then secondary treatment, and perhaps advanced or tertiary

We need to remove the wastewater pollutants to protect the environment and protect public health. When water is used by college students, the water becomes contaminated with pollutants. If left untreated, these pollutants would negatively affect our water environment. For example, organic matter can cause oxygen depletion and pollute the college environment. This biological decomposition of organics could produce foul odors. Waterborne diseases are also eliminated through proper wastewater treatment. Additionally, there are many pollutants that could exhibit toxic effects in college which also be avoided.

- To protect the aquatic life from the toxicity wastes
- To make the wastewater 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 dealing[17]with water supply network in the campus.Try to find out the water subsidy if any[17]provided to the campus residents.

The Main Objectives Of The Present Study Were:

- 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).
- To establish the nature of the relationship between the water quality parameters using correlation analysis.

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:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

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

Methodology

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 considersation to afew general classes of compounds.

All the types of the physical parameters are performed on site by direct appearance. The physical test are 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 scare 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 test 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. Following different physic chemical parameters are tested regularly for monitoring quality of water.

The physic-chemical analysis of water has been done in three season, samples were collected for three seasons i.e. Pre-Monsoon, Monsoon & Post-Monsoon. The samples were of Grab samples & collected in sterilized bottles using standard procedure (APHA, 1995).

Material and Method

In the preparation of reagents chemicals of analytical Analar grade were used with deionised water. All glass ware were cleaned and rinsed with detergents and immersed in 25% nitric acid and finally rinsed with de ionized water.

Sampling

Alard college campus water coming through the hostel from washing area, bath, kitchen etc, those have create unhygienic condition. Sampling is done using triplicate clean or in new polyethene plastic containers which were covered with black polyethene bags to prevent growth of Algae. The pH and conductivity, ware determined immediately after sampling and the sample was stored at a temperature below 4°C, this is to prevent the growth of microorganisms.

All the parameters were analyzed by using standard methods (Kodarkar, 1992), (APHA-AWWA-WPCF 1999), (APHA, 2005). Table-I

Different parameters are analyzed and procedure employed for measuring these parameters are given in the table –I

Result of these parameters is given in the Table –II, and compared with standard values recommended by World Health Organization (WHO 1997).

Methods employed for the measurement of physico-chemical parameters of various water samples Table-I

S. No.	Parameters	Method
1	pH	pH metry
2	Temperature (˚C)	Thermometry
3	Electrical conductivity (μm/cm)	Conductometric
4	Turbidity (NTU)	Nephelometry (Electronic)
5	TDS (mg L-1)	Gravimetric
6	Total alkalinity (mg L-1)	Titrimetric
7	TH (mg L-1)	Complexometric Titration (EDTA)
8	Chloride (Cl-) (mg L-1)	Gravimetric
9	DO (as O2, mg L-1)	Winkler's method
10	Potassium (mg L-1)	FLame Photometric Meth
11	Zinc (mg L-1)	Atomic Absorption Spectrometer
12	Copper	Atomic Absorption Spectrometer
13	BOD	Titrimetric
14	COD	pen Reflux Method
15	Oil and grease	Partition-gravimetric metho

Table-II The values of physico-chemical parameters of ACEM water during May - June 2016

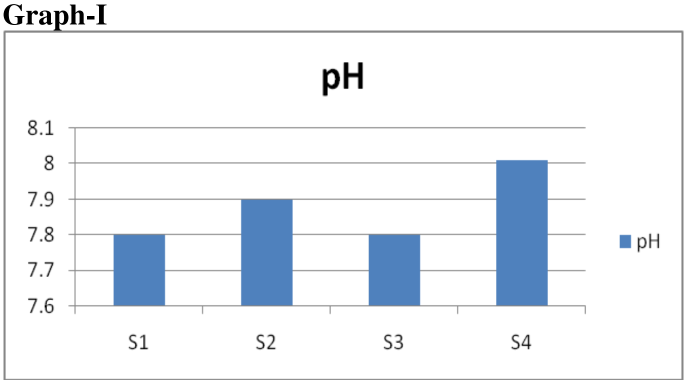
Sr. No.	Parameters	Samples				WHO 1997	ISO10500-91
		S1	S2	S3	S4		
1	pH	7.8	7.9	7.8	8.01	6.5-8.5	6.5-8.5
2	Temperature	25.2	25.2	25.0	25.0	-	-
3	EC, μm/cm	490.0	490.0	426.0	300.0	300	-
4	Turbidity, NTU	10	40	60	120	5.0	10
5	TDS, mg/L	386.0	386.0	390.0	258.0	600	500
6	Alkalinity mg/L	15	20	30	80	-	200 ppm
7	Total Iron mg/L	0	1	2	3		
8	DO, mg/L	2.3	6.0	5.8	5.0	6.0	5.0
9	Zinc, mg/L	0.1	0.1	1	2		
10	Copper, mg/L	0	0	0.2	0.2		
11	Chloride, mg/L	3.5	60	50	120	250 ppm	250 ppm
12	Potassium, mg/L	2	3	6	12		
13	B.O.D	18.0	18	19	18	6	30
14	C.O.D.	48	43	45	50	10	-
15	Oil and Grease	nil	nil	nil	nil		

Table-III and IV Linear correlation coefficient and regression equation for pairs of parameters having significant values

Sr. No	Pairs of parameters	R2	Regression coefficient		regression equation
			a	b	
1	EC and TDS	0.9313	0.672	68.09	TDS=0.672(EC)+68.09
2	Turbidityand Alkalinity	0.9653	0.619	0.617	Alkalinity=0.619(Turbidity) +0.617
3	Alkalinity and Total Iron	0.9484	0.03	0.646	Total Iron=0.030(alkalinity)+0.646
4	Total Iron and Zinc	0.9996	0.945	0.854	Zinc=0.954(total Iron)+0.854
5	Total Iron and copper	0.9045	0.109	0.09	copper=0.109(total iron)-0.09
6	Zinc and potassium	0.9898	4.918	1.815	Potassium=4.918(zinc)+1.815

	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
pH	1														
Temperature	-0.3171	1													
EC, µm/cm	-0.7514	0.81864	1												
Turbidity, NTU	0.81513	-0.8078	-0.9641	1											
TDS, mg/L	-0.8887	0.55331	0.93134	-0.8861	1										
Alkalinity mg/L	0.84413	-0.7259	-0.9873	0.96525	-0.9717	1									
Total Iron mg/L	0.65198	-0.9045	-0.9854	0.95549	-0.8557	0.94843	1								
DO, mg/L	0.33133	-0.4231	-0.2364	0.4743	-0.0746	0.23671	0.30108	1							
Zinc, mg/L	0.66912	-0.8926	-0.9896	0.95873	-0.8694	0.95649	0.99963	0.29135	1						
Copper, mg/L	0.31715	-1	-0.8186	0.80778	-0.5533	0.7259	0.90453	0.42312	0.89261	1					
Chloride, mg/L	0.91085	-1	-0.8682	0.96008	-0.8522	0.90727	0.83505	0.58386	0.84197	0.64191	1				
Potassium, mg/L	0.76756	-0.834	-0.9953	0.98456	-0.9148	0.98411	0.98644	0.32898	0.98979	0.83395	0.9038	1			
B.O.D	-0.516	-0.5774	-0.0037	0.03587	0.36067	-0.1397	0.17408	0.40063	0.14724	0.57735	0.03704	0.03704	1		
C.O.D.	0.51602	0.57735	0.00372	-0.0359	-0.3607	0.1397	-0.1741	-0.4006	-0.1472	-0.5774	0.11658	-0.037	-1	1	

Graph-I



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 negative logarithm of concentration of hydrogen ion gives the pH of a sample. The pH value of water sample 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.

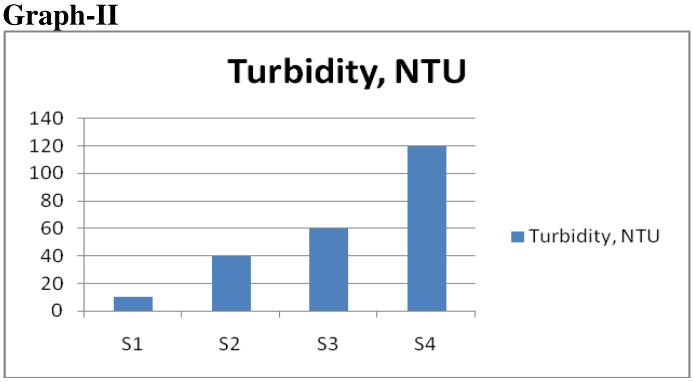
PH values are generally determined electrometrically or calorimetrically. The electrometric method is more accurate but requires special apparatus. The calorimetric method is simple and requires less expensive apparatus, and is sufficiently accurate for general work pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity(Gupta et al.,2009). pH of samples of Alard College of Engineering and Management lies in between 7 to 7.54 which is within the limit prescribed by WHO. Means **Graph-I**

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-II

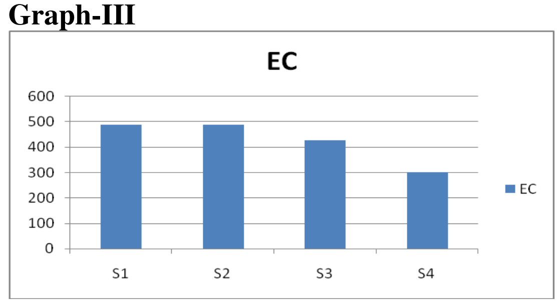


Electrical Conductivity (EC)

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 the eight parameters of physicochemical analysis of water these are(1)temperature, as the temperature increase the conductivity of water increases, (2)pHvalue, (3)alkalinity (4)hardness total solids, (5)total dissolved solids, (6) chemical oxygen demand(7) chloride and (8)iron concentration of water.(Navneet Kumar et al., 2010)all the parameters shows deflection in detected value when there will be increases and decrease in conductivity

EC values indicate salt content is evaluated in water (Harilal et al.,2004).Water purity is evaluated by Electrical conductivity(Acharya G.D et al.,2008).

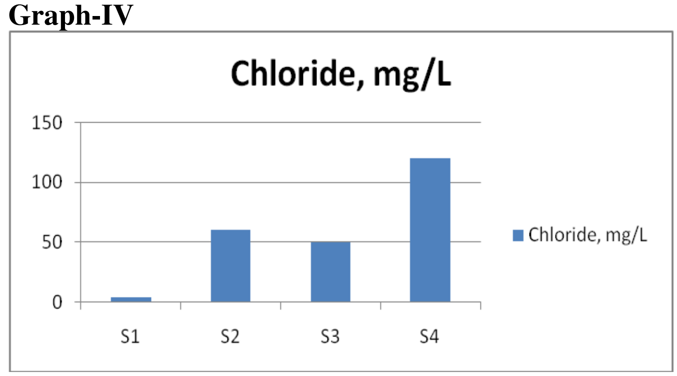
Graph-III



Chloride:

Chloride content of the water samples were found to be in the range 3.5 to 120mg/L. All the values were within the prescribed limit. Water additive used to control microbes, disinfect, but no such purification process is performed yet. The water coming from the hostel, canteen, washing area was poured as such. No treatment process yet was performed in this part of the water. If such type of water is used for the Eye/nose irritation; stomach discomfort. Increase corrosive character of water. Elevates levels of threat to infrastructure, such as road beds, bridges, and industrial pipe (Kelly et al., 2012).

Graph-IV



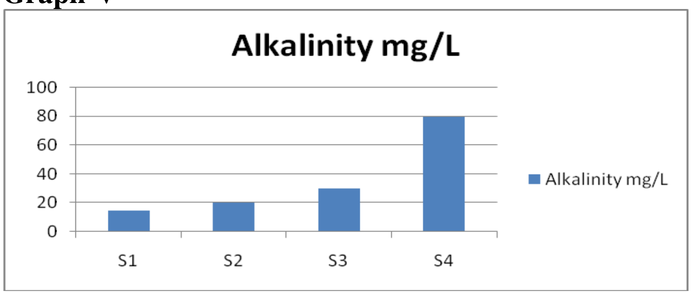
Alkalinity

The alkalinity values were found 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-V



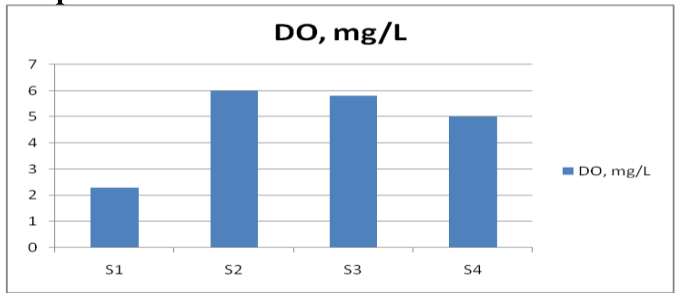
Dissolved oxygen (DO)

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. A low DO (less than 2mg/l) would indicate poor water quality and thus would have difficulty in sustaining many sensitive 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 (Kemker, 2013).Less D.O. 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). DO in sample is measured titrimetrically by Winkler's method after 5 days incubation at 293 K. The difference in initial and final DO gives the amount of oxygen consumed by the bacteria during this period. This procedure needs special BOD bottles which seal the inside environment from atmospheric oxygen.

The apparatus used are:

- Incubation bottles
- DO meter
- Air incubator

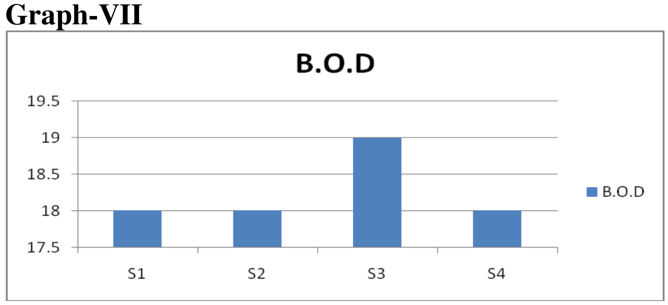
Graph-VI



BOD

The amount of oxygen required to oxidize ubstance to carbon dioxide and water may be calculated by stiochiometery 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 –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 18.0-19.0mg/L. The permissible limit for [4]drinking water is 30mg/L. BOD values were[4]observed within the limit for all the samples. All the values are determined using standard laboratory techniques, at a temperature of 20oC.The standard test condition lets in incubating the sample in an air tight bottle, in dark at a required temperature for specific time.

Graph-VII



Chemical Oxygen demand (COD)

COD values of the analyzed water samples were found 48-50mg/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.

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 3mg/l, Zinc is 0.1 to 2 mg/L and Copper content range from 0 to 0.2 mg/L. values for water samples. The principle associated here is a light beam is guided through the flame into mono-cremator and then to a detector that measures the amount of light absorbed by the atomized element 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 proportional to the concentration of the element in the sample.

The predicted and observed values of TDS on the basis of EC and alkalinity on the basis of turbidityTable-V and VI

Site Code	Turbidity	Alkalinity	
		Predicted	observed
S1	10	10	15
S2	40	13	20
S3	60	19	30
S4	120	50	80

Site Code	EC	TDS	
		Predicted	observed
S1	490	327	386
S2	490	327	386
S3	426	330	390
S4	300	241	258

A correlation matrix for different water quality variables is depicted in **Table-IV**. 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. **Table-V** and **VI**.

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 ISI 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 well 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. 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.

References

[1] Acharya GD, Hathi MV, Patel AD, Parmar KC (2008) Chemical properties of groundwater in Bhiloda Taluka Region, North Gujarat, India. E- Journal of Chemistry 5(4):792 – 796.
[2] APHA (2005) Standard methods for the examination of water and waste water, 21st edn. American Public Health Association, Washington DC.
[3] APHA-AWWA-WPCF (1999) Standard methods for the examination of water and wastewater, 20th edn. American Public Health Association, Washington.
[4] Gupta, D. P., Sunita and J. P. Saharan, (2009),Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India, Researcher, 1(2), pp 1-5.
[5] Harilal CC, Hashim A, Arun PR and Baji S (2004) Hydrogeochemistry of two rivers of Kerala with special reference to drinking water quality. J Ecology Environ Conservation, 10(2):187-192.
[6] Kanase D.G. et al(2014): physico-chemical assessment of Krishna river at Karad, Satara district (Maharashtra):IOSR, Volume 8, Issue 6, pp 25-32.
[7] Kelly WR, Panno SV, Hackley K (2012) The sources, distribution, and trends of chloride in the waters of Illinois Bulletin B-74 Illinois state water survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, Champaign, Illinois.
[8] Kemker C (2013) Dissolved Oxygen. Fundamentals of Environmental measurements. Fondriest Environ
[9] Kodarkar MS (1992) Methodology for water analysis: Physico-chemical, biological and microbiological. Indi Asso Biologists Hyderabad 2:50.
[10] Navneet, Kumar, D. K. Sinha, (2010),Drinking water quality management through correlation studies among various physicochemical parameters: A case

study, International Journal of Environmental Sciences, 1(2), pp 253-259.
[11] Panasiuk O, Hedström A, Marsalek J, Ashley RM, Viklander M (2015) Contamination of storm water by wastewater: A review of detection methods. Journal of Environmental Management 152:241-250.
[12] Sanders KT (2015) Critical review: Uncharted waters.The future of the electricity-water nexus. Environmental Science and Technology 49(1):51-66.
[13] Singh D and Jangde AK (2013) Studies of physicochemical parameter of River Belgirinalla, CG, India. Int Res J Environment Sci 2(3): 41-45.
[14] Tanakakis, V.E.; Paranychianakis, N.V.; Angelakis, A.N. (2007) Soil as a wastewater treatment system: Historical development. Water Sci. Technol.: Water Supply, 7, 67–76.
[15] Van Leeuwen CJ (2013) City Blueprints: Baseline assessments of sustainable water management in 11 cities of the future. Water Resour Manage 27:5191–5206. doi:10.1007/s11269-013-0462-5.
[16] Wellen C, Kamran-Disfani AR, Arhonditsis GB, (2015) Evaluation of the current state of distributed watershed nutrient water quality modelling. Environmental Science and Technology 49 (6): 3278-3290.
[17] Yadav J, Pathak RK, Khan E (2013) Analysis of water quality using Physicochemical Parameters, Satak Reservoir in Khargone District, MP, India. Int Res J Environment Sci 2(1): 9-11.