Research Article

Water quality and sediment analysis at selected locations of Pavana river of Pune district, Maharashtra

[1]Mane A. V., [2]Pardeshi R. G., [3]Gore V. R., [3]Walave R. L., [3]Manjrekar S. S. and [3]Sutar G. N.

[1]Department of Environmental Sciences, Fergusson College, Pune
[2]Fergusson College, Pune
[3]Department of Chemistry, Fergusson College, Pune

_____

ABSTRACT

Water pollution is one of the major global environmental problems. It is an acute problem almost in all major rivers and water reservoirs in India. Water pollution is increasing and becoming severe day-by-day and posing a great risk to human health and other living organisms. There is growing concern on the deterioration of ground water quality due to geogenic and anthropogenic activities. Present investigation aims at insight about the level of contaminants of surface water, groundwater and sediment analysis of selected locations of Pavana river of Pimpri-Chinchwad area of Pune district. An attempt has been made to assess the water quality, sediment and weed analysis of the samples. A higher value of TDS was observed at groundwater site G4 with 834.27 mg/l while it was lower at surface water site 1 by 65.12 mg/l. Dissolved oxygen content of the water samples was observed quite well in limit but it was lower with 1.6 mg/l at surface water site 4 while higher at surface water site 2 with 5.23 mg/l. In the present study, highest value of COD was observed by value of 120 at surface water site S4 while was lowest with only 64 mg/l at groundwater site G4. As expected groundwater samples showed higher values of hardness content as compared to surface water samples of Pavana river. Nickel content was found to be present at all sites with a range of 22 to 40 mg/kg. There is urgent need for more representative samples to be used to go beyond preliminary assessment as reported in the present study for making appropriate recommendations.

Keywords: Heavy Metals, Pavana River, Physicochemical Parameters, Sediment and Weed Analysis, Water Quality
_____

INTRODUCTION

Water is one of the most common yet the most precious resources on earth without which there would be no life on Earth. Nowadays, water pollution is a major global problem. It is an acute problem almost in all major rivers and dams in India. Water pollution is increasing and becoming severe day-by-day and posing a great risk to human health and other living organisms. Water pollution can be defined as 'The **c**ontamination of water bodies by physicochemical and biological pollutants into the water making it unfit for drinking and use in other purposes'. Point source pollution refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch while non-point source pollution refers to diffuse contamination that does not originate from a single discrete source. The change water quality also varies due to a change in chemical composition of the underlying sediments and aquifer [1]. About one third of the drinking water requirement of the world is obtained from surface sources like rivers, dams, lakes and canals [2]. In urban areas, the careless disposal of industrial effluents and other

_____

wastes in rivers and lakes may contribute greatly to the poor quality of river water [3]. Pollution of river in India has now reached to a point of crisis due to unplanned urbanization and rapid growth of industrialization [4].

Assessment of water resource quality of any region is an important aspect of developmental activities of the region, because rivers, lakes and manmade reservoirs are used for water supply to domestic, industrial, agricultural and fish culture [5]. Good water quality resources depends on large number of physicochemical parameters and the magnitude and source of any pollution load; and to assess that, monitoring of these parameters is essential [6]. Polluted water is the major cause for the spread of many epidemics and some serious diseases like cholera, tuberculosis, typhoid, diarrhea etc. Contamination of drinking water from any source is therefore of primary importance because of the danger and risk of water borne diseases [7]. According to WHO, 1998, report there were estimated 4 billion cases of diarrhea and 2.2 million deaths annually [8]. The availability of good quality water is an indispensable feature for preventing disease and improving quality of life [9]. Domestic and industrial wastewater constitute as a constant polluting source, whereas surface runoff is a seasonal phenomenon mainly controlled by climate [10]. Without adequate quantity and quality of fresh water sustainable development will not be possible [11]. The healthy aquatic ecosystem is depended on the biological diversity and Physico-chemical characteristics [12]. The physicochemical properties will also help in the identification of sources of pollution, for conducting further investigations on the eco-biological impacts and also for initiating necessary steps for remedial actions in case of polluted water bodies[13]. In India, many researchers have worked on physicochemical and biological characteristics of reservoirs and rivers [4, 14, 15, 16, 17, 18, 19, 20]. Although statistics vary, the World Health Organization (WHO) reports that approximately 36% of urban and 65% of rural Indian's were without access to safe drinking water [21].

Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes. There is growing concern on the deterioration of ground water quality due to geogenic and anthropogenic activities. Thus, Freshwater has become a scare commodity due to over exploitation and pollution [22]. Uncontrolled domestic wastewater discharge into pond has resulted in eutrophication of ponds as evidence by substantial algal bloom, dissolve oxygen depletion in the subsurface water leads to large fish kill and other oxygen requiring organism [23]. The natural and human activities over the years have contributed towards continuous built up of toxic metals in water bodies. Human activities such as mining and smelting of metals, electroplating, gas exhaust, energy and fuel production, fertilizers, sewage and pesticides, municipal waste generations are contributing for heavy metal pollution [24] which has become one of the most severe environmental problems today. The content of heavy metals in river bottom sediments is often used as an indicator of their anthropogenic pollution [25]. In most of the rivers contaminated sediment has become one of the most environmental issues. Both natural and human activities effect the composition of the sediment [26]. It is also well known that river bottom sediments are not only sinks for heavy metals but also their sources. Though some of the metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for life processes in plants and microorganisms, while many other metals like Cd, Cr and Pb have no known physiological activity, but they are proved detrimental beyond certain limit [27]. Monitoring these metals is an important task for safety assessment of the overall environment.
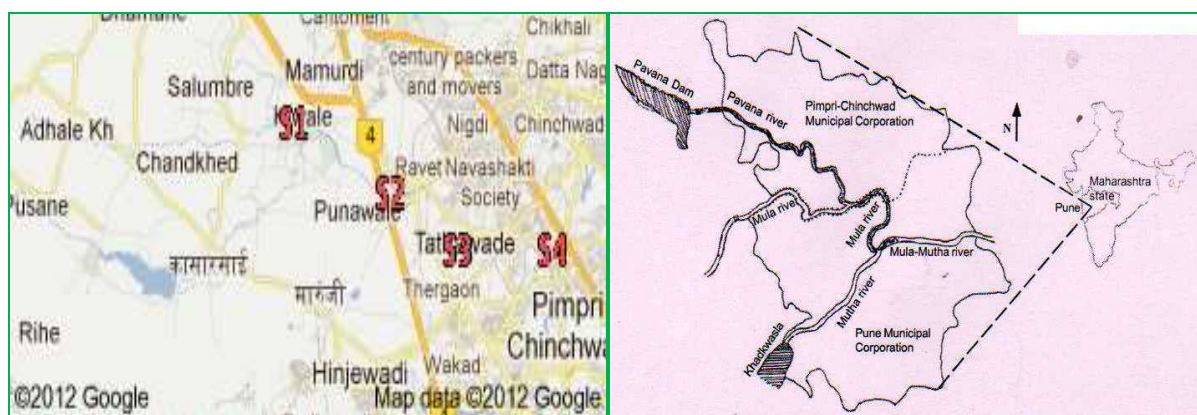

Fig. 1: Map of Pavana River Study Area Showing Selected Sites (Pimpri-Chinchvad, Pune).

_____

Pavana river flows through the cities of Pimpri and Chinchwad. Due to outburst of rapid industrialization and urbanization of these cities, Pavana carries huge load of sediments, chemicals and varied industrial discharges. There is an urgent need to monitor the water quality of the river periodically; therefore, present investigation aims at insight about the level of contaminants of surface water, groundwater and sediment analysis of selected locations at Pavana river of Pimpri-Chinchwad area of Pune district. Sediment and weed analysis was carried out in order to find out the extent of metal accumulation and biological magnification.

EXPERIMENTAL SECTION

All standard and well-known methods were used for the estimation of physico-chemical parameters of water and sediment analysis of the samples collected from selected sites of the city. Samples were collected from four sites of Pavana river, Pimpri-Chinchvad of Pune district. The study was carried out in the month of January 2012. The distance between each site was nearly about 2 km. Ground water, surface water, sediments and weed samples were collected from each site. Each water sample is collected in 1000 ml plastic container while dissolved oxygen was fixed on site and then analyzed in the laboratory. Sediment samples and weed samples were collected in plastic bags and treated further in laboratory for analysis. All water samples were preserved carefully. Weed and sediment samples were dried in oven and powdered form was used for further analysis. Metal concentrations were determined by using Atomic Absorption Spectroscopy (AAS) while other water parameters were estimated by using routine laboratory instruments. Each parameter was estimated for two times and average value was considered as final result.

2.1 Selected Sites:
Total of four sites were selected namely; site 1: Kivalegaon, site 2: Ravet-Punavale bridge, site 3: Chinchvadgaon and site 4:Kalewadi Phata

2.2 Physico-Chemical Parameters:
2.2.1 pH:
The pH was determined using ELICO-LI 127 pH meter. The pH of water sample was directly determined with the electrode while pH of the sediment sample was determined by preparing (1:5, sediment: water) suspension in distilled water. The contents were stirred well and allowed to settle and supernatant was used to check pH.

2.2.2 Electrical Conductivity (EC) and Total Dissolved Solid (TDS):
EC of the water samples and sediment suspension was measured by using ELICO EC-TDS meter (CM 183, Make-India) where electrode was directly dipped into the respective solutions for the direct display of result on a digital scale. It was reported in micro Siemens (μS). The clear supernatant used for pH was also used for EC measurement. The TDS was measured on EC-TDS meter by using the same supernatant with the help of electrode to get direct digital display as a reading in mg/l.

2.2.3 Dissolved Oxygen (DO):
Dissolved oxygen content of the water samples was measured by using Winkler's method (modified azide method). The sample was collected in 300 ml bottle and DO was fixed on site by using 1 ml each of Manganous sulphate and Alkaline-iodide-azide. The precipitate formed was dissolved in laboratory by using sulphuric acid and titrated with sodium thiosulphate using starch as an indicator. The end point of titration was blue to straw pale colour.

$$DO\,(mg/L) = \frac{ml\,of\,titrant\ x\ N\ x\,1000\,x\,8}{V2(V1 - V2)/V1}$$

V1=volume of BOD bottle, V2=volume of content titrated and V= volume of $MnSO_4$ and Alkaline-iodide-azide

2.2.4 Chemical Oxygen Demand (COD):
COD determination was carried out with dichromate reflux method with the addition of 10 ml of 0.25 N potassium dichromate ($K_2Cr_2O_7$) and 30 ml H_2SO_4+Ag_2SO_4 reagent in 20 ml diluted sample. The mixture was refluxed for 2h and was cooled to room temperature. The solution was then diluted to 150 ml by using distilled water and excess $K_2Cr_2O_7$ remained was titrated with ferrous ammonium sulphate (FAS) using ferroin indicator.

_____

$$COD\,(mg/L) = \frac{(A - B)\;x\;N\;x\;1000\;x\;8}{Volume\,of\,Sample}$$

Where, A is the ml of FAS used for blank; B is the ml of FAS used for sample, N is the normality of FAS and 8 is milli equivalent weight of oxygen

2.2.5 Biological Oxygen Demand:
The dilution method was followed to determine the BOD after three days at 27 ^{o}C. For the same dilution water was prepared with the addition of nutrients namely phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride. The diluted sample was transferred to BOD bottles of 300 ml capacity. After determining initial dissolved oxygen (DO), final DO was estimated from the bottles kept for incubation period for three days.

2.2.6 Alkalinity of Water sample:
100 ml of water sample was mixed with 2-3 drop of phenolphthalein. The development of pink colour to the solution indicated the presence of alkalinity and was then titrated with 0.02N H_2SO_4 till the colour disappears.

$$Alkalinity = \frac{B\;x\;N\;x\;50\;x\;1000}{Volume\,of\,Sample}$$

2.2.7 Total Hardness of Water sample:
The total hardness of the water samples was determined by EDTA titration method where 50 ml of well mixed sample was mixed with 1-2 ml buffer of pH 10 and a pinch of Eriochrome black-T indicator. The contents were then titrated with0.01M EDTA till wine red solution changes to blue.

$$Hardness(mg/L) = \frac{C\;x\;D\;x\;1000}{ml\,of\,Sample}$$

Where C=ml of EDTA for titration, D= mg of $CaCO_3$equivalent to 1ml of EDTA

2.2.8 Free Carbon dioxide of Water sample:
Free CO_2 was determined with 100 ml of sample in a conical flask and with the addition of phenolphthalein indicator. Colorless solution was then titrated with 0.05N NaOH to obtain pink as an end point.

$$Free\,CO2 = \frac{A\;x\;N\;x\;44\;x\;1000}{Volume\,of\,Sample}$$

A= ml of titrant.
N= normality of NaOH

2.2.9 Total Phosphorous as Phosphate:
20 ml of sample was added with phenolphthalein and strong acid was used to discharge the colour obtained. 4ml of ammonium molybdate reagent and 0.5ml of stannous chloride reagent was added to the sample. The absorbance of the blue coloured solution was recorded after 10 minutes but before 20 min spectrophotometrically at 690 nm. Calibration curve in the range of 0.3 to 2.0 mg/l of phosphate was drawn using distilled water and all chemicals as blank.

$$Phosphate\;=\frac{Garaph\;reading\;x\;1000}{Volume\;of\;Sample}$$

2.2.10 Organic Carbon in Sediment:
0.50 g dried soil sample was taken in a conical flask. 10 ml 1 N Potassium dichromate and 2 ml con. $H_2SO_4$was added and allowed to stand for 30 min. the volume was adjusted with 200 ml distilled water and then 10 ml

_____

orthophosphoric acid and 1 ml Diphenyl amine indicator was added. The solution thus obtained was titrated with 0.5 N FAS solution. End point was blue-violet to green. Similarly blank was run with distilled water.

$$\text{Organic carbon (\%)} = \frac{10(B - T) \times 0.003 \times 100}{B \times S}$$

B= Vol. of FAS for blank, T= Vol. of FAS for soil sample, S= Wt. of soil in gm.

2.2.11 Heavy Metal Analysis in Water, Sediment and Weeds by using Atomic Absorption Spectroscopy:
Heavy metals i.e. Cu, Fe, Ni and Pb were detected by using Spectr-AA 220 of VARIAN Company. 100 ml of water sample was filtered through Whatman 42 filter paper and was used for further analysis. Extract form 1 g well dried weed sample and sediment sample was to estimate the heavy metals. The sample was taken in a 150 ml clean beaker and to that 10 ml con. Nitric acid was added. It was covered with a watch glass and kept for an hour till the primary reactions subsided. It was then heated on hot plate until all the material was completely dissolved. It was allowed to cool to room temperature and then 10 ml of Perchloric acid (60%) was added to it and mixed thoroughly. It was then heated strongly on the hot plate until the solution became colorless and reduced to about 2-3 ml. While heating, the solution was not allowed to dry. After cooling, it was transferred quantitatively to 100 ml capacity volumetric flask, diluted to 100 ml with D.W. and kept overnight. Next day it was filtered through Whatman No. 44 filter paper. The filtrate was stored properly and used for analysis of selected inorganic constituents.

2.2.12 Residue Analysis of an Organophosphate Pesticide in Weed by using HPLC:
Chlopyrifos is a toxic crystalline organophosphate insecticide. It is also known as "O,O diethyl-O-(3,5,6-trichloro-2-pyridinyl) phosphorothioate". Stock standard solutions were prepared by accurately weighing 0.0104 g of standard chlorpyrifos and dissolved 100 ml methanol. Working standard solutions of 0.1 ppm, 0.5 ppm, 1 ppm and 2 ppm were prepared by dilution with methanol. A high performance liquid chromatography (HPLC) Agilent 1100, equipped with UV-Visible detector was used for analysis of chlorpyrifos residue, containing Zorbax RX C18 as a column. Mobile phase was a combination of acetonitrile (82.5%), Water (17%) and acetic acid (0.5%). Wavelength used was 240 nm and injection volume was 20 microliter.

Extraction: The entire sample (50 g of plant) was grinded and paste was made. 10 g of grinded sample was weighed and to it 20 g anhydrous sodium sulphate and 2.5 g of pure sodium chloride was added. The mixture was dissolved in 100 ml of solvent (methanol). Blended it on high speed varying blender for 3 minutes and was filtered through 0.4 micrometer filter paper. The filtrate was concentrated on rotary evaporator and dried on hot plate. Finally it was dissolved in 100% solvent and analyzed by HPLC.

RESULTS AND DISCUSSION

Table 1: Water Quality Analysis of the Samples Collected from Selected Areas of Pavana River in January 2012

Sr. No.	Site	Parameters									
		pH	EC	TDS	DO	COD	BOD	Alkalinity	Free CO$_2$	Hardness	PO$_4$
BIS 10500 Standards mg/l		*6.5 to 8.5*	-	*500 Drinking*	-	*250 Discharge limit*	*30 Discharge limit*	*200 Drinking*	-	*300 Drinking*	*5 Discharge limit*
1)	S1	8.12 (±0.02)	130.43 (±1.41)	65.12 (±0.95)	4.83 (±0.21)	107 (±5.05)	33.75 (±1.24)	72 (±1.10)	4.4 (±0.23)	58 (±2.10)	17.85 (±1.24)
2)	S2	7.86 (±0.04)	164.13 (±2.92)	82.13 (±1.41)	3.23 (±0.15)	105 (±2.17)	46.2 (± 1.34)	64 (± 3.42)	10.12 (±1.13)	72.6 (±3.81)	20.8 (±1.24)
3)	S3	7.72 (±0.02)	249.27 (±4.58)	124.33 (±2.51)	5.23 (±0.09)	114 (±2.20)	51.24 (±2.5)	188 (±2.10)	17.6 (±1.85)	86 (±3.10)	7.38 (±1.01)
4)	S4	7.39 (±0.05)	408.12 (±4.23)	195.61 (±5.0)	1.6 (±0.14)	120 (±3.26)	35.1 (±1.48)	216 (±3.56)	48.4 (±2.14)	111.2 (±4.15)	10.46 (±1.23)
5)	G1	7.34 (±0.02)	782.24 (±4.16)	391.48 (±4.58)	2.63 (±0.13)	74 (±3.15)	5.62 (±2.46)	296 (±4.74)	44 (±2.19)	356 (±6.04)	22.76 (±1.24)
6)	G2	7.82 (±0.04)	201.13 (±5.24)	101.86 (±2.87)	3.03 (±0.17)	81 (±4.05)	6.22 (±3.14)	92 (±277)	17.6 (±1.05)	90 (±2.10)	13.53 (±2.18)
7)	G3	7.75 (±0.01)	709.31 (±3..28)	353.33 (±5.23)	4.6 (±0.11)	70 (±1.1)	6.25 (±1.89)	276 (±3.41)	30.8 (±2.18)	261.2 (±2.49)	12.3 (±1.98)
8)	G4	7.56 (±0.01)	834.27 (±6.07)	416.24 (±6.24)	3.2 (±0.21)	64 (±2.25)	2.81 (±1.7)	248 (±3.87)	39.6 (±1.48)	183.2 (±3.55)	12.92 (±0.94)

(Each value is mean of two determinations)
All values are in mg/l except pH (unitless) while EC in µS

_____

Table 2: Sediment Analysis of the Samples Collected from Various Sites
(1:10 Suspension in Water)

| Sr. No.	Name of the site	Parameters			
		pH	EC (µS)	TDS (ppm)	Organic Carbon (%)
1)	SD1	6.82 (±0.03)	246.33 (±8.62)	123.3 (±1.52)	2.76 (±0.1)
2)	SD2	7.48 (±0.04)	242.47 (±1.73)	119.45 (±1.23)	2.62 (±0.40)
3)	SD3	7.58 (±0.02)	236.66 (±3.21)	149.54 (±2.14)	2.3 (±0.15)
4)	SD4	7.08 (±0.01)	498.61 (±5.19)	248.71 (±3.19)	3.37 (±0.56)

Each value is mean of two determinations

Table 3: Heavy Metal Contents of the Various Samples

Sr. No.	site	Water Analysis (mg/l)			
		Cu	Fe	Ni	Pb
BIS 10500 Standards (Drinking Water)		*0.05*	*0.3*	*3.0 Discharge standard*	*0.1*
		Surface Water			
1)	S1	ND	ND	0.5	ND
2)	S2	0.42	4.4	1.4	ND
3)	S3	ND	31.04	13.28	ND
4)	S4	0.38	11.34	8.52	0.2
		Groundwater Water			
1)	G1	0.52	ND	0.48	ND
2)	G2	0.64	0.36	0.82	0.62
3)	G3	ND	4.5	0.64	2.4
4)	G4	0.314	0.74	1.06	1.94
		Sediment Analysis (mg/kg)			
1)	SD1	272	ND	22	68
2)	SD2	102	16	34	78
3)	SD3	122	582.8	32	82
4)	SD4	194	302.4	40	104
		Weed Analysis (mg/kg) (*Parthenium hysterophorus*)			
1)	W1	45.6	13	14	10
2)	W2	59.4	19.4	18	6
3)	W3	72.4	204	12.2	ND
4)	W4	106.4	274	16	2

Residue Analysis of an Organophosphate Pesticide Chlorpyrifos in *Parthenium hysterophorus* by using HPLC:
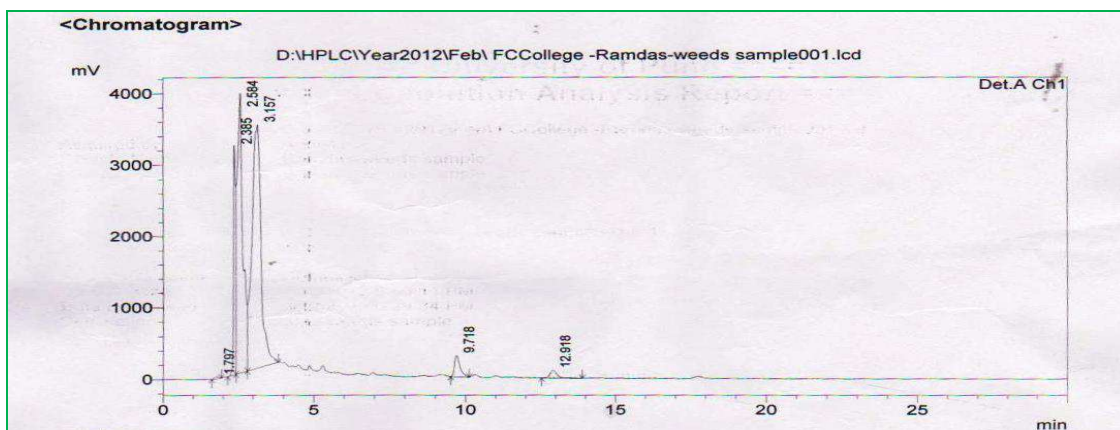
A) Standard Chromatogram for chlorpyrifos (o,o diethyl-o-(3,5,6-trichloro-2-pyridinyl) phosphorothioate):

_____
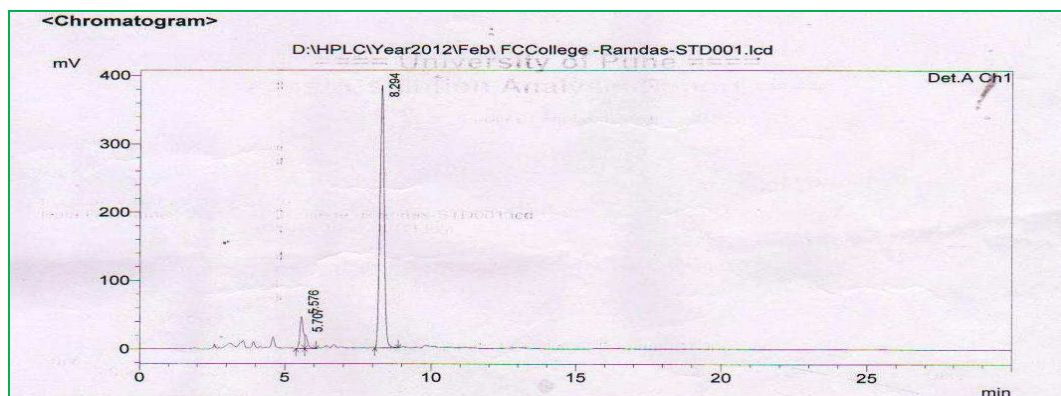
B)   Water sample (Site 1): (Absent)
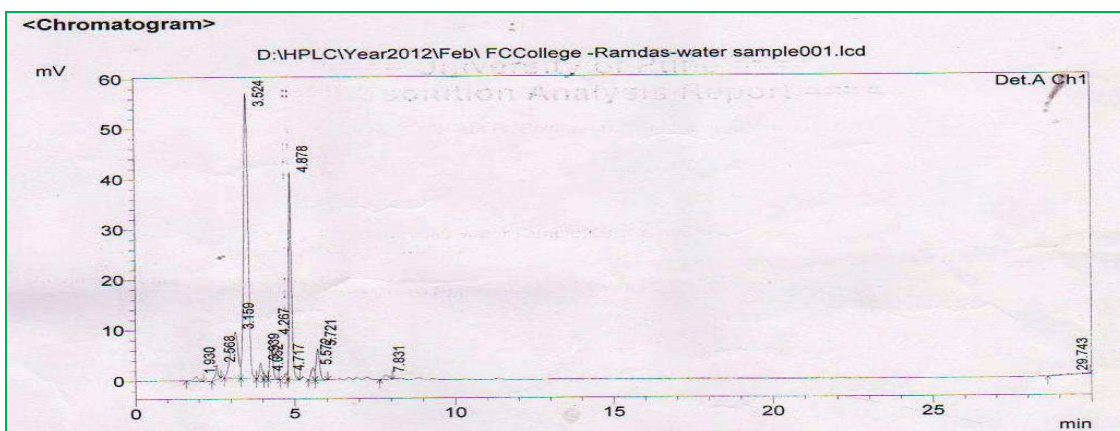
C) Weeds sample (Site 1): (Absent)

The peak of standard chlorpyrifos was obtained at 8.29 min by HPLC, but was not observed in water and weed sample at the respective time interval which shows the absence of chlorpyrifos in water and weed sample.

3.1 pH:
pH is the measurement of the potential activity of hydrogen ions in the sample. By the definition, pH is the negative logarithm of hydrogen ion concentration, more precisely hydrogen ion activity. pH of the water body is affected by several factors. pH is not static, it changes over time, in fact it changes over the course of an hour or day. The leaching of soils, organic matter and rocks is influenced by pH. The desirable range of pH for drinking water is from 7.0 to 8.5. The majority of waters are slightly basic (i.e. generally over 7.0) because of the presence of carbonate and bicarbonate ions. In the present investigation, the minimum pH was observed to be 7.34 of ground water of site 1 while maximum as 8.12 was observed of the surface water of site 1. All the pH values were in normal range and as per acceptable limit with slightly alkaline values. Generally, the obtained pH values fall within the World Health Organization standard of 7.0 to 8.5 and the water quality ranges 6.5 to 8.5 for drinking water and water meant for full contact recreation, respectively [28]. The EU also sets pH protection limits of 6.0 to 9.0 for fisheries and aquatic life [29]. The fluctuations in optimum pH ranges may lead to an increase or decrease in the toxicity of poisons in water bodies [30].

3.2 Electrical Conductivity (EC):
Electrical conductivity or specific conductance is the reciprocal quantity and measures a material's ability to conduct an electric current. Electrical conductivity in the water is due to salt present in water and current produced by them [31]. Increasing levels of conductivity and cations are the products of decomposition and mineralization of organic

_____

materials [32]. In the present investigation, highest value of EC was observed in the groundwater sample at site 4 with 834.27 µS while the lowest was observed at site 1 of the river water by a value of 130.43 µS. In general it was observed that the groundwater samples were with higher EC values as compared to surface water of the river and might be due to more number of dissolved substances and compounds in the groundwater. Higher content of EC at site G4 might be also due to the discharge of industrial wastes.

3.3 Total Dissolved Solids (TDS):

In general, all groundwater sites showed higher value of TDS content as compared to surface water of the river. Higher values of TDS was observed at groundwater site G$ with 834.27 mg/l while it was lower at surface water site 1 by 65.12 mg/l. TDS indicate the general trend of the surface quality or salinity of the surface water bodies. In water, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium and other particles. In water, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles [33].

3.4 Dissolved Oxygen (DO):

Dissolved oxygen concentrations in unpolluted water normally range between 8 and 10 mg/l and concentrations below 5 mg/l adversely affect aquatic life [34]. DO standard for drinking purpose is 6 mg/l whereas for sustaining fish and aquatic life is 4-5 mg/L [34]. For water quality variable such as dissolved oxygen, water quality criteria are set at the minimum acceptable concentration to ensure the maintenance of biological function. Dissolved oxygen content of the water samples were observed quite well but it was lower with 1.6 mg/l at surface water site 4 while higher at surface water site 2 with 5.23 mg/l. Biological oxygen demand increases due to biodegradation of organic materials which exerts oxygen tension in a water body [35]. Dissolved oxygen present in drinking water adds taste and it is highly fluctuating factor in water [36].

3.5 Chemical Oxygen Demand (COD):

Chemical oxygen demand is an important water quality parameter in order to assess the pollution load into the water source. COD is the measure of amount of oxygen required by both potassium dichromate and concentrated sulphuric acid to breakdown both organic and inorganic matters. It is commonly used to indirectly measure the amount of organic compounds in water. The measure of COD determines the quantities of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water [37]. In the present study, highest value of COD was observed by value of 120 at surface water site S4 while lowest was with only 64 mg/l at groundwater site G4. In the conjunction with the BOD test, the COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances [38].

3.6 Biological Oxygen Demand (BOD):

Biological oxygen demand is the measure of oxygen required by microorganisms whilst breaking down organic matter. Highest value of BOD was observed by vale of 51.24 at surface water sample site S3 while lowest was with only 2.81 mg/l at groundwater site G4. All the sites thus indicated the higher values for BOD and are the indication of organic load on the water source. BOD is used as the index of organic pollution of waste water that can be decomposed by bacteria under anaerobic conditions.

3.7 Alkalinity:

Alkalinity measures the ability of a solution to neutralize acids the equivalence point of carbonate or bicarbonate. In the natural environment carbonate alkalinity tends to make up most of the total alkalinity due to the common occurrence and dissolution of carbonate rocks and presence of carbon dioxide in the atmosphere. Alkalinity of the water samples was quite high with highest value (296 mg/l) at groundwater site G1. The lower value was observed at surface water sample of river by value of 64 mg/l.

3.8 Free CO_2:

Free CO_2 content of the water bodies also represents the rate of degradation and release of CO_2 in water bodies which later again decrease the dissolved oxygen content of the water bodies. The value was highest at surface water river sample with 48.4 mg/l indicating higher release of CO_2 due to degradation of organic wastes. The lower value was observed at the by a value of 10.12 mg/l at surface water site S2. According to Dwivedi and Pandey [39] concentration of free CO2 in water increases due to Increasing algal blooms which creates a barrier between atmosphere and water for gaseous exchange.

_____

3.9 Hardness:
Total hardness mainly depends upon the dissolved salts present in water. Hard water is water that contains high levels of dissolved calcium, magnesium and other mineral salt such as iron. The greater is amount of dissolved minerals in water, more is the water hard. Hard water forms deposits that clog plumbing. These deposits, called scale, are composed mainly of calcium carbonate, magnesium hydroxide and calcium sulphate. As expected groundwater samples showed higher values of hardness content as compared to surface water samples of the Pavana river. The higher value of hardness was observed at groundwater sample site G1 by 356 mg/l while it was lower by a value of 58 mg/l at surface water site S1.

3.10 Phosphate (PO$_4$):
Phosphate content was more by a value 22.76 mg/l at groundwater site G1 while lower was observed at surface water site S3. It is often a limiting nutrient in environments, and its availability may govern the rate of growth of organisms. In the context of pollution, phosphates are one component of total dissolved solids, a major indicator of water quality and can cause eutrophication with algal blooms or favoring typical indicator species of pollution. Changes in water chemistry parameters resulted in an increase in nutrient status of water bodies, which in turn supports profuse growth of nuisance species such as *Eichhornia* besides providing suitable habitat for disease vectors and exert unnecessary economic pressure on local management for its control.

3.11 Sediment Analysis:
Sediment analysis collected from the river bed showed slightly acidic pH at site 1 when 1:10 suspension was made in distilled water while all other sediments showed slightly alkaline pH ranging from 7.08 to 7.48. Electrical conductivity ranged from 242.47 to 498.61 µS. TDS content was observed higher at site 4 by a value of 248.71 mg/l while it was lowest by 119.45 mg/l at site 2. Organic carbon content was higher at site 4 and is the indication of higher fertility of the sediment soil. All the sites showed good amount of organic carbon content.

3.12 Heavy Metal Analysis:
3.12.1 Heavy Metals in Water:
Copper content of the water samples was observed to be absent at Surface water sites S1 and S3 while it was absent at G3 site. Highest copper content was observed at groundwater site G2 by a value of 0.64 mg/l while lowest by 0.38 mg/l at S4. Iron content was higher at S3 with 31.04 mg/l and observed to be less at all groundwater samples as compared to S3 and S4. The lowest content was observed at 0.36 mg/l at G2 while it was absent at S1 and G1. Nickel content was also much higher at S3 similar to that of iron. Its content was higher by a value of 13.28 mg/l at S3 while lower in all groundwater samples. Nickel was found to be present in all the surface and groundwater samples. Lead content was observed to be present higher by a value of 2.4 mg/l at G3 while it was found to be absent at S1, S2, S3 and G1. Overall its content was found to be less as compared to all the other metals estimated. Such variations in the water quality depend on the regional differences in climate, geology, land use and population distribution [40]. The presence of heavy metals even in traces is toxic and detrimental to both flora and fauna. Metals after entering the water many be taken up by fauna and flora and eventually, accumulated in marine organisms that are consumed by human being [41].

3.12.2 Heavy Metals in Sediment:
Sediment is the loose sand, clay, silt and other soil particles that settle at the bottom of a body of water (United State Environmental Protection [42]. It has been described as the ultimate sink of contaminants in the aquatic system [43]. Riverbed sediment was also analyzed for selected metals and their deposition. Copper content varied in the range of 102 mg/kg (SD2) to 272 mg/kg (SD1) at the four selected sites. Iron content was much higher at SD3 (582.8 mg/kg) and SD4 (302.4 mg/kg) as compared to first two sites. It was absent at SD1. Nickel content was found to be present at all sites with a range of 22 to 40 mg/kg. It was higher at SD4. Similar to nickel, lead content was also found at all the sediment collection sites. Its content varied by the range 68 to 104 mg/kg. It was higher at SD4. Metals such as Cd, Cr and Pb have higher possibilities of interacting with organic matter in the aqueous phase and settling, thus reflecting in the high concentration of these metals in the sediment [44]. The mechanisms by which trace elements are taken up by the sediments include, adsorption to clays, metal oxides/hydroxides and organic matter, biological uptake, and physical accumulation of metal-enriched particulate material by sedimentation and entrainment [45]. Our values of sediment analysis are in consistent with Hagan et al. [46].

_____

3.12.3 Heavy Metals in Weed:
Selected heavy metals were also detected form the weed *Parthenium hysterophorus* in order to check the metal accumulation by a way of magnification. It was observed that all the four selected metal showed metal accumulation in the weed samples as compared to water samples and this is the clear cut indication of bio-magnification. The value of copper content was highest at W4 site (106.4 mg/kg) and lowest at W1 (45.6 mg/kg). Iron found to be accumulated at all weed samples and was much higher by a value of 204 mg/kg (W3) and 274 mg/kg (W4) as compared to W1 and W2. Nickel content was higher by a value of 18 mg/kg at W2 while lower at W3 by 12.2 mg/kg. Lead content was observed to be less as compared to all other metals studied. It was absent at W3 while higher by a value 10 mg/kg at W1.

3.13 Absence of Organic Pesticide, Chlorpyrifos:
Agrochemicals have a special place in agriculture but may harmful for the human health and safety of mammals due to their toxic nature. A pesticide, chlorpyrifos was studied for its possible presence as it is used in agriculture as well as in urban areas. It is very toxic in nature. The chlorpyrifos (o,o diethyl-o-(3,5,6-trichloro-2-pyridinyl phosphorothioate) pesticide was observed to be absent in water and weed samples. The representative chromatograms of water and weed samples along with standard of chlorpyrifos is shown in the figures. This reflects a good indication that though the water and sediment were more or less contaminated with metals but not with this type of organic pesticide. Beside the runoff from agricultural fields, the agriculture practices in the dry bed of rivers, which are common in India also, add pesticides to the river during monsoon. The use of endosulfan is banned in more than 60 countries but India has been the world's largest producer and consumer of endosulfan with a total use of 113 000 tonnes from 1958 to 2000 [47]. Recently, the supreme court of India has put a temporary ban on agricultural use of pesticides (Writ petition 213, 2011), but the impacts of this ban could only be noticed after decades.

CONCLUSION

In the present investigation, an attempt has been made to assess water quality with reference to physicochemical properties, heavy metals, sediment and weed analysis of the riverine area of Pavana. Chinchwad is a major industrial hub and hosts one of the biggest industrial zones in Asia. This town is home to the Indian operations of major automobile companies, several industries, manufacturing units etc. leading to various kinds of pollution. The site 3 and site 4 were observed to be polluted because of industries around and their discharges. The site 4 was highly polluted in relation with higher free CO_2 and alkalinity as compared to site 3. Higher values of TDS, EC also indicate more pollution at site 4. The concentration of heavy metals was also observed to higher at site 3 and site 4 as compared to other two sites indicating pollution of surface, ground water, sediment and weed sample. Lead (Pb) is highly toxic to humans and was also observed to be present in some samples. The parameters DO, COD, BOD, Alkalinity, Total Hardness, Total Phosphorous and Free CO_2 were varying significantly due to different environmental conditions and wastewater receiving sites located at the bank of river. Sediments collected form four different sites also showed higher levels of heavy metals and is the clear indication of contamination. Weed *Parthenium hysterophorus* showed accumulation of heavy metals and indicates higher levels of heavy metals in water body. Sources of wastewater from industries and residential areas, washing clothes, cars and dumping of garbage was observed on these sites. It was also observed that the natural quality of water resources is getting deteriorated at faster rate. Further studies are needed with an extensive and continuous study on the analysis of sediments for other priority pollutants and monitoring the area of influence. More representative samples should be used to go beyond preliminary assessment as reported in the present study and thereby making appropriate recommendations. At last we also recommend that the surface and groundwater monitoring should be carried out on planned basis and frequently by respective government departments. Such type of monitoring studies should go beyond nominal water parameters and should have a standard list of parameters as suggested by international agencies like World Health Organization including heavy metals, various group of pesticides and micro pollutants of special importance to ecosystems.

_____

REFERENCES

[1] A Jameel; *Indian J. Env. Proct*., 44(2), 108-112 (**2002**).

[2] SB Jonnalagada; and G Mhere, *Water Res*., 35: 2371-2376 (**2001**).

[3] V Emongor; E Kealotswe; I Koorapetse; S Sankwasa and S Keikanetswe., *Journal of Applied Sciences*. 5,147-150 (**2005**).

[4] DN Saksena; RK Garg and RJ Rao, *Journal Of Environmental Biology*, 29(5), 01-710 (**2008**).

[5] GR Jackher; and M Rawat, *India. J. Aqua. Biol*., 18: 79-83 (**2003**).

[6] KR Reddi, N Jayaraju; I Suriyakumar; and K Sreenivas, *Ind. J. Mar. Sci.,* 22: 223-234 (**1993**).

[7] MO Edema; AM Omemu; OM Fapetu; *Niger. J. Microbiol*. 15(1): 57-61 (**2001**).

[8] CL Chan, MK Zalifah; and AS Norrakiah, *The Malaysian Journal of Analytical Science*, 11 (2), 414-420 (**2007**).

[9] AO Oluduro; BI Adewoye; *J. Plant Sci*. 6. 453-438 (**2007**).

[10] KP Singh; A Malik; D Mohan and S Sinha, *Water Res.,* 38, 3980 (**2004**).

[11] HB Mahananda, MR Mahananda; and BP Mohanty, *Ecology Environment & Conservation*.11 (3-4), 537-541 (**2005**).

[12] K Venkatesharaju; P Ravikumar; RK Somashekar; KL Prakash, *Journal of Science, Engineering and Technology*, 6(1), 50-59 (**2010**).

[13] UK Ekwenye; CA Oji, *Environ. Ecol*. 26: 543-545, (**2008**).

[14] RK Trivedy; and PK Goel, Environmental Publication, Karad, Maharashtra(**1986**).

[15] GR Jakhar; SC Bhargava; and RK Sinha, Geobiology (**1990**).

[16] S Rao; Fresh Water Molluscs of Indian Recent Advances in Fresh Water. Anmol Publications Pvt. Ltd. New Delhi Pp. 47-52 (**1993**).

[17] S Patil; and JM Patwari*; J. Aquatic Biology*, Vol. 18(2): 85-86 (**2003**).

[18] A Shayestehfar; M Soleimani; SN Mousavi; and F Shirazi, *Iran Journal of Environmental Biology*, 29(5), Pp 715-720 (**2008**).

[19] RN Barik; and RK Patel, *Indian Journal of Environmental Protection*, 24 (03), 161-166 (**2004**).

[20] RK Gaur; AA Khan; A Alam; and Md A Alam, *Indian Journal Of Environmental Protection*, 20(3), 165-170 (**1997**).

[21] World Health Organization, Guidelines for Drinking water quality, Volume 1: 3rd edition, WHO Press, Switzerland (**2009**).

[22] GK Gupta; R. Shukle, *Pollution Research*, 23 (4): 205-209(**2006**).

[23] Pandey, *Hydrol. Proc*., 10 (2), 131-295 (165 Pages) (**2003**).

[24] A Amman; B Michalke; P Schramel, *Anal. Biochem*., 372, 448-452 (**2002**).

[25] E Helios-Rybicks*;* Researches of Quaternary Sediments. Polish Geological Institute (**1995**).

[26] AK Rai; SN Upadhyay; S Kumar and YD Upadhyay*, J. of IAEM* .25:22-51 (**1999**).

[27] MR Bruins; S Kapil; FW. Oehme, *Ecot ox. Environ.Safe*. 45, 198-207 (**2000**).

[28] DWAF, 1996, South African Water Quality Guidelines, (Volume 2), Recreational Water Use (2nd Ed.). Department of DWAF, WRC, (**1995**), South African Water Quality Management Series. WRC Report No. 24 TT 64/94. Department Of Water Affairs and Forestry and Water Research Commission, Pretoria.

[29] D Chapman, Water Quality Assessments: A Guide To The Use Of Biota, Sediments And Water In Environmental Monitoring 2nd. Ed. UNESCO, World Health Organization, United Nations Environment Programme, London (**1996**).

[30] J Ali, **1991**, An Assessment Of The Water Quality Of Ogunpa River Ibadan, Nigeria. M.Sc.Dissertation. University Of Ibadan, Ibadan, Nigeria.

[31] HA Solanki; PU Verma and DK Chandawat, *Life Sciences Leaflets* 20:944-955(**2011**).

[33] MR Mahananda, *International Journal of Research and Review in Applied Sciences*, 2 (3), 284-295 (**2010**).

[34] PV Rao, Textbook Of Environmental Engineering. Eastern Economy Ed., Pretice-Hall Of India Private Limited, New Delhi, Chapter 3, 280 (**2005**).

[35] B Abida and H krishna, *Journal of Chemistry*, 5(2):377-384 (**2008**).

[36] N Patil; A Ahmed; H Sureshbabu; NM Kottureshwar; M Jayashree and J Nijalingappa, *IJABPT*. 1(2): 518-523 (**2010**).

[37] F Ngwenya; Water Quality Trends in the Eerste River, Western Cape, 1990- 2005. A mini thesis submitted in partial fulfillment of the requirements for the degree of Magister Scientiae, Integrated Water Resources Management in the Faculty of Natural Science, University of the Western Cape, pp 41 (**2006**).

[38] CN Sawyer; LP Mccarty and GF Parkin, Chemistry for Environmental Engineering and Science, 5th Edition,Tata Mcgraw-Hill, 625-630 (**2003**).

_____

[39] BK Dwivedi and GC Pandey. *Poll. Res.*21(3):361-370 (**2002**).

[40] AJ Robson; and C Neal*, Sci. Total Environ*., 194-95: 15-37(**1997**).

[41] SS Asaolu; KO Ipinmoroti; CE Adeyinowo, O.Olaofe, *Afr. J. Sci* 1: 55-61(**1997**).

[42] USEPA; United States Environmental Protection Agency, Water Quality Monitoring For Coffee Creek (Porter County, Indiana). Retrieved Sept. 29, 2006, www.USEPA(**2002**).

[43] AP Mucha; MTSD Vasconcelos; and AA Bordalo, *Environmental Pollution* 121: 169 -180 (**2003**).

[44] EC, European Commission,Heavy Metals In Waste. Final Report DG ENV. E3. 86 (**2002**)

[45] BT Hart; *Hydrobiologia*, 91: 299-313(**1982**).

[46] GB Hagan; FG Ofosu; EK Hayford; EK Osae; and K Oduro-Afriyie, *Research Journal of Environmental and Earth Sciences* 3(4): 385-392, (**2011**).

[47] NGBRA: National Ganga River Basin Authority (NGRBA), Draft, Environmental and Social Management Framework (ESMF), Volume I - Environmental and Social Analysis, **2011**, available at:

http://moef.nic.in/downloads/public-information.