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Impact of Urbanisation on the Quality of Ground Water in the Ramnadi Basin, Pune

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Water is an essential and valuable natural resource for entire living community. Hence its quality and quantity are of prime importance. The importance of quality and quantity of natural resources of water, that is ground water and surface water is significantly increasing since last two decades in India. This is because of uncertainties of water resources and challenges of quality of surface water as well as ground water due to reckless human activities under the name of development. Increasing population growth, urbanisation and industrial development, excess use of fertilizers, etc., has added to the degradation of the natural resources of water. Ground water which acts as reservoir changes qualitatively due to the pollution and indiscriminate disposal of industrial waste, human and agricultural water. This has created a threat not only to the quality of ground as well as surface water resources in the many regions, to the hydrological ecosystem as a whole. In view of this, the paper evaluates the impact of urbanisation on the quality of the water resources around the Ramnadi basin.

KEYWORD

Pollution, Urbanisation, Natural water resources, Ground water, Surface water, Human activities, Industrial waste.

INTRODUCTION

Water is the valuable natural resource and its quality is of much concerned for the welfare of human being. Recently, frequent and indiscriminate exploitation and destruction of natural resources of water have largely disturbed the ecosystem of water. Human activities that involve industrial and agricultural development, over use of fertilizers, inadequate management of land, urbanization, land use patterns have directly or indirectly degraded the natural resources of surface water as well as ground water. The impact of the quality and quantity of water resources has lead to the infertility of land. The importance of ground and surface waters is significantly increasing since last two decades in India, because of uncertainty of surface water resources, population growth and industrial development (Saboo, 2003). These have lead to the scarcity of drinking water. Ground water acts as reservoir, which qualitatively changes due to the pollution, indiscriminate disposal of industrial waste, human and agricultural water. This has created threat to the quality of ground water as well as surface water in many regions (Rengaraj, 1996; Tyagi, 2000). Murgesan *et al.* (2005) have reported the physico-chemical characteristics of bore well samples from urban stations in Madurai region. Naik *et. al.* (2005) have analysed the ground water resource at Arisekere, Karnakata to study the fluoride toxicity. Their study revealed the fluoride contamination of the ground water resource. Verghese et al. (2005), Mishra and Sultana (2005) have studied the quality of surface wate. Bhanja *et al.* (2000), Padmanabha and Bengali (2005), Jameel and Hussain (2005) have discussed the water quality index. The water quality index is defined as a rating reflecting the composite influence of different water quality parameters on overall quality of water (Padmanabha and Bengali, 2005). Chemical weathering and mass transfer in the area of Ramnadi basin was discussed elsewhere (Gujrathi, 1992). But the assessment of water quality has not been addressed so far to the author's

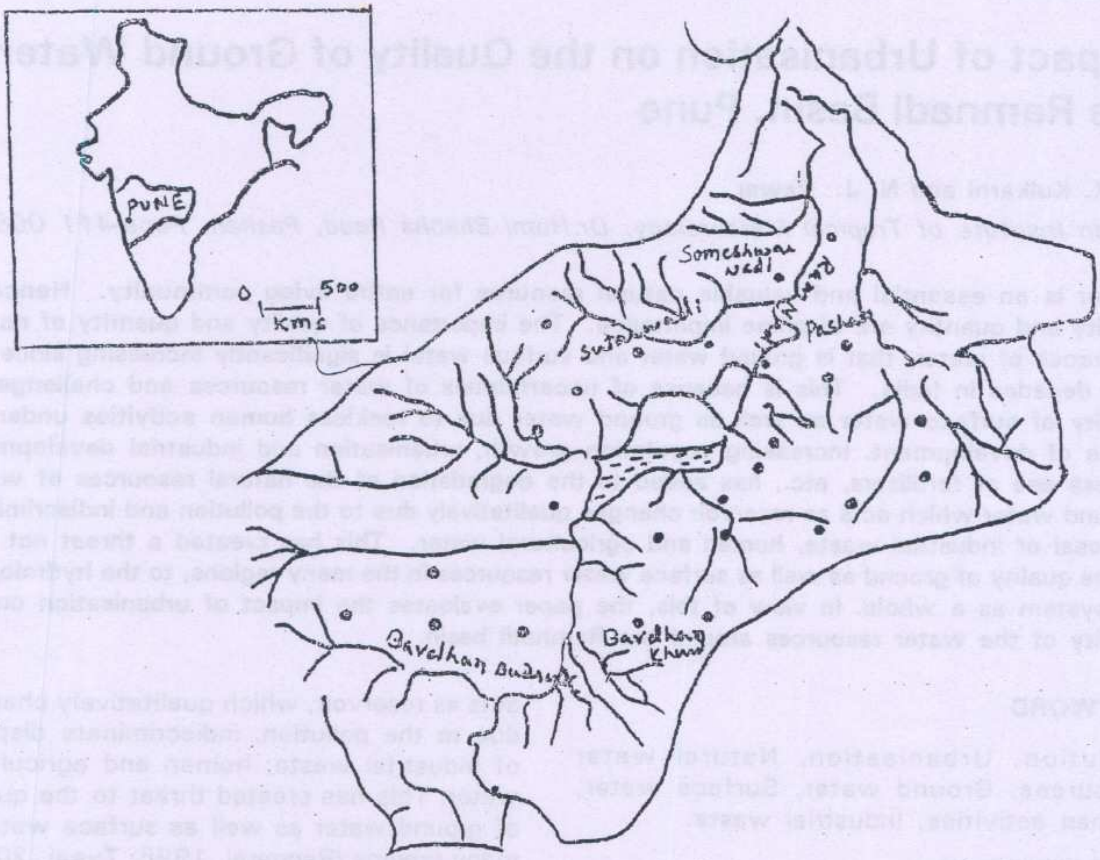

Figure 1. *Map of Ramnadi river basin with locations of sampling sites*

knowledge. The area is undergoing fast urbanization process and hence an effort has been made to study its impact on the quality of ground water in the Ramnadi basin.

Scope of work

The area under study forms sub-urban environment, which was known for its picturesque, tranquil surroundings, and its proximity to the University and Chandani chouwk. A number of strategically important Institutions, National Defense Academy, ERDL, Armament Research and Development Establishment, Indian Institute of Tropical Meteorology, National Chemical Laboratory, Chaturshrungi Water Treatment Centre, Pune (rural) Police Head quarters, and the famous Pashan lake which is a popular weekend get-away and draws Picnickers in droves during the hot summer months.

Recent five years, this area is undergoing vigorous, full-scale construction activity. Lots of residential and shopping complexes have come up. Also, a number of restaurants and hotels have sprung up and thereby villages are turning into towns and towns are turning into cities. This process, which is called as the urbanization is an important index of economic growth, at national as well as regional levels (Patil, 2001). This urbanization is nothing but an increase in the proportion of urban population to total population over a period of time. Cities create their own environments and as they do so, they exert powerful effects on the natural resources. Especially, the construction works in cities are made of concrete, asphalt, brick, stone and steel. These materials absorb and reflect energy differently than vegetation and soil. They

Table 1(a). *Water quality parameters for water wamples*

Sample no.	Temp., °C	pH	EC,μ mhos	Na, ppb	K, ppb	Ca, mg/L	Mg, mg/L	Cl_2, mg/L	HCO_3, ppb
1	21.8	7.23	0.545	275.0	120.0	92.99	3.22	49.70	175.00
2	21.5	8.30	0.950	345.0	40.0	149.90	3.27	113.60	170.00
3	22.0	8.35	1.022	360.0	100.0	146.69	3.28	160.46	155.00
4	22.1	8.26	0.587	295.0	110.0	101.00	2.94	49.70	160.00
5	22.0	7.50	0.679	90.0	130.0	89.96	2.76	7.10	160.00
6	21.9	7.21	1.023	295.0	160.0	114.63	3.22	117.86	190.00
7	22.0	7.85	0.899	293.0	60.0	108.22	3.16	69.58	165.00
8	21.5	8.02	1.073	296.0	90.0	102.60	3.24	93.72	220.00
9	22.0	8.00	0.960	351.0	60.0	156.3	3.31	93.72	200.00
10	22.0	8.12	1.006	362.0	125.0	172.34	3.36	108.92	200.00
11	21.8	8.06	1.314	280.0	80.0	163.53	3.42	156.20	220.00
12	22.0	8.02	0.699	295.0	110.0	160.32	3.23	76.68	180.00
13	21.8	8.00	0.988	120.0	90.0	116.23	3.05	92.30	215.00
14	22.0	8.20	1.517	362.0	75.0	99.40	3.01	99.40	150.00
15	22.5	8.02	0.995	320.0	110.0	140.28	3.41	122.12	195.00
16	23.4	8.16	1.378	315.0	125.0	148.30	3.46	103.66	220.00
17	23.0	8.26	1.840	470.0	370.0	339.88	3.55	197.38	285.00
18	22.8	7.90	0.969	252.0	112.0	124.25	3.37	291.10	195.00
19	22.9	8.10	0.720	120.0	100.0	56.91	1.95	110.76	140.00
20	22.0	8.20	0.150	80.0	340.0	32.87	1.69	110.76	65.00
21	23.0	8.29	0.067	45.0	105.0	32.06	1.68	72.42	45.00
22	22.8	8.60	0.667	468.0	155.0	76.15	3.11	73.84	160.00
23	22.0	8.50	1.119	286.0	130.0	148.30	3.40	197.38	195.00
24	24.2	8.79	0.622	466.0	36.0	105.01	3.44	245.66	170.00
25	23.0	8.84	0.991	295.0	—	145.09	3.32	343.64	270.00

absorb more radiant energy and radiate this energy back into the atmosphere at different times through the day. This heat influences air circulation and precipitation patterns. Incidentally, with increasing construction activity, farmers are selling off their plots to builders making way for mega residential complexes and multi-storied buildings. But the area is noted for brick kilns, which pollute the surrounding area.

Study area

The area considered under the study covers the Ramnadi basin. The basin area lies between 18° 30′ and 18° 35′ N, latitude and 73° 45′ to 73° 50′ E longitudes and measures about 108 km². Ramnadi is a tributary of the river Mula. It originates in the hilly areas of Bavdhan khurd and Bavdhan budruk and later joins Mula river at Aundh. The Pashan lake is built on the river. The Pashan lake occupies an area of about 5.76 km². Pune Muncipal Corporation has reserved the area surrounding the Pashan lake for the plantation program. Unfortunately, chemical effluents drained through the factories are polluting the famous Pashan lake. In the recent past, this lake attracted a number of migratory and other birds, and even plans were designed for setting up of a bird sanctuary over here. However, over the past few years there has been a considerable drop in the number of birds visiting the lake and reasons for the same are not to seek. Ironically, the Pashan lake receives very little water in the recent years.

Once the water body used to attract birds, both resident and migratory, the lake today is a little more than stagnant water, which is concerned much in view of the environ-

Table 1(b). *Trace elements for water samples, in ppb*

Sample no.	Fe	Mn	Cu	Pb	Zn
1	30.0	30.0	50.0	20.0	70.0
2	10.0	30.0	20.0	20.0	260.0
3	40.0	20.0	10.0	30.0	140.0
4	70.0	30.0	40.0	10.0	120.0
5	10.0	20.0	30.0	30.0	140.0
6	50.0	20.0	10.0	10.0	50.0
7	00.0	30.0	00.0	20.0	70.0
8	00.0	30.0	20.0	20.0	50.0
9	30.0	30.0	10.0	20.0	60.0
10	00.0	20.0	10.0	30.0	70.0
11	00.0	40.0	10.0	40.0	180.0
12	20.0	30.0	10.0	40.0	70.0
13	00.0	30.0	20.0	50.0	340.0
14	00.0	30.0	10.0	50.0	110.0
15	70.0	20.0	30.0	30.0	90.0
16	60.0	20.0	10.0	30.0	120.0
17	160.0	10.0	10.0	30.0	90.0
18	120.0	10.0	10.0	30.0	260.0
19	130.0	10.0	10.0	40.0	110.0
20	200.0	10.0	10.0	50.0	60.0
21	220.0	10.0	20.0	40.0	10.0
22	270.0	10.0	10.0	60.0z	10.0
23	230.0	00.0	00.0	50.0	90.0
24	230.0	10.0	10.0	30.0	330.0
25	120.0	20.0	10.0	40.0	000.0

ment, since the habitat of these very birds is getting disturbed. The depth of the lake, which was at one time, at least 50 feet has today become about 20 feet due to the silt collected in it. Since the Ramnadi is the tributary of the river Mula, the climatic conditions of the Mula river basin is taken as the representative of the Ramnadi basin. The annual average rainfall is 670 mm. The mean daily maximum and the mean daily minimum temperature for the hottest month-May is 40°C and 23°C, respectively. Daily individual maximum temperature ranges from 43–44°C. The evening sea breeze from west/northwest keeps the city summer nights at bearable levels. The same for the coldest month of December are 30°C and 12°C, respectively. The relative humidity ranges from 36% in March to 81% in August. Three fourths of the annual rainfall of 67 cm occurs in just four months from June to September (Weather Report, IMD, Pune)

METHODOLOGY

The area under consideration covers Sutarwadi, Someshwarwadi, Sus road, Bavdhan Budruk, Bavdhan khurd and Pashan. The area is comprised of a number of bore wells. The water samples were collected and temperature and pH were recorded at the site itself for water samples. The sites of the sample collection are marked by the dots in the map of Ramnadi basin (Figure 1). Various analytical techniques, such as Titrimetric method, Flame photometric method, Atomic absorption spectrophotometric method, were used to estimate the constituent of water and soil samples.

Titrimetric methods : Chlorides, total hardness, calcium, magnesium and total alkalinity were estimated by using the titrimetric methods (Trivedy and Goel, 1984).

Flame photometric method : Sodium and potassium were determined by using flame photometer. The characteristic radiation for sodium and potassium are 589 nm and 768 nm, respectively, the intensity of which can be read in a scale by using a filter for this wavelength (Trivedy and Goel, 1984).

Atomic absorption spectrophotometric method : Atomic absorption spectrophotometry utilizes the phenomenon that atoms absorb radiation of particular wavelength. By atomic absorption spectrophotometer, the trace elements, like copper, iron, zinc, lead, manganese, etc., in water samples, were estimated using atomic absorption spectrophotometer (Trivedy and Goel, 1984).

RESULT AND DISCUSSION

Table 1 (a) shows water quality parameters, such as temperature, pH, electrical conductivity, sodium, potassium, calcium, magnesium, chlorides and bicarbonates of the water samples collected in Ramnadi basin. Temperature is basically an important parameter because of its effects on the chemical and biological reactions, on the organisms in water. A rise in temperature

increases the speed of chemical reaction. Water temperature of the range 7-11°C imparts a pleasant taste and has refreshing quality. At higher temperature water is tasteless and cannot quench the thirst. Temperature is very important in the determination of various other parameters, such as electrical conductivity, pH, etc. Temperature data is also important in the industries for calculating heat transmission, for cooling towers and process use. The temperature of the samples varies between 21.5 to 24.2°C.

The pH is the measure of the acidity or alkalinity of water and measured in terms hydrogen ion concentrations in water. The pH plays a vital role in the waste treatment and for fixing alum dose in the water supply. All the water samples have the pH in the range of 7.2–8.8, which is within the maximum permissible range of 6.5–9.2 (WHO, 1971) and ICMR (7.0–8.5). The pH of the water samples indicates the neutral to alkaline nature which may be due to the presence of bicarbonates which undergo hydrolysis in solution (Langer *et al.*, 2003). Conductivity is the capability of a solution to conduct the electric current since most of the salts present in ionic forms, are therefore capable of conducting current. Therefore conductivity is considered to be a rapid and good measure of dissolved solids. Conductivity of distilled water ranges between 1-5μmhos and the presence of salts and contaminants will increase the conductivity of the solution. A sudden increase in conductivity of the water is the indicator of the addition of the pollutant, to the water (Trivedy and Goel, 1984). Conductivity is an important criterion in determining the suitability of water and wastewater for irrigation. Conductivity of the samples under study varied from 0.067 to 1.84μmhos.

Chlorides occur naturally in all types of water but the concentration is very low in natural water. The most important source of chlorides in the water is the discharges of domestic sewage, and industrial waste. Threshhold value for chloride is 250-500 mg/L, although chloride concentration up to 500 mg/L is harmless. Chlorides are responsible for brackish taste of water and are an indicator of sewage pollution because of the chloride content of urine. Concentration of chlorides for the samples under study varied from 7.1-343 mg/L. Higher values of chloride indicate pollution of water. Alkalinity is due to the presence of bicarbonates, carbonates or hydroxides (Trivedy and Goel, 1984). Most of the alkalinity of water is because of the bicarbonates produced by interaction of ground water with limestone. Alkalinity is useful since it provides buffering to resist changes in pH. The amount of alkalinity present is expressed in terms of calcium carbonate. Alkalinity itself is not harmful to human beings; still water supplies with less than 100 mg/L are desirable for domestic use (Trivedy and Goel, 1984). Only two samples recorded alkalinity below 100 mg/L. For rest of the samples, the alkalinity lies between 140–270 mg/L. This indicates that rock weathering is potential source of alkalinity in the area. WHO prescribed limit of alkalinity for drinking water is 120g/L. Present water samples show higher alkalinity.

Sodium is one of the important cations occurring in natural water. The concentration in natural freshwater is lower than Ca and Mg. Major source of sodium in natural water is weathering of various rocks. Most of the industrial wastes and domestic sewage are rich in sodium and increase its concentration in natural waters after disposal. Higher concentration of sodium in the irrigation water and soil solution is of considerable interest as it affects soil permeability and texture, and leads to puddling and reduced rate of water intake. A higher concentration of Na is harmful to human health. The variation of sodium in the water samples is from 45-470 ppb. Higher values of Na indicate higher rock-water interaction or addition for pollution source. Potassium is also a naturally occurring element however the concentration remains lower than the sodium, calcium and magnesium. Like sodium

weathering of rocks is the major source in natural waters and wastewater disposal increases the concentration. It is not much significant as far as human health is concerned but large quantities may be laxative. The concent-ration of potassium in water samples ranges from 36-160 ppb. Except for two sites it is higher (340 and 370 ppb).

Calcium is one of the most abundant substances of the natural waters. Since it is present in high quantities in the rocks and is leached out from there to contaminate the water. In natural water the quantity varies from 10-100 mg/L depending upon the types of the rocks. Concentrations up to 1800 mg/L have been found not to impair any physiological reaction in man (Lehr *et. al.,* 1980). Water with high concentration of calcium is not useful for domestic use. Small concentrations are beneficial in reducing the corrosions in the pipe. It antagonizes the toxicity of various substances, such as Pb, Zn, Al and toxic solutions of Na, Mg, K, and Cl_2. In the present samples, only one sample reported higher calcium content (340mg/L) and for rest of the samples the concentration ranges from 32–172 mg/L. Mg also occurs in all natural waters but in lower concentration than Ca. The sources of Mg in natural waters are the various types of rocks industrial waste and sewage. It is a non-toxic at the concentration generally met with natural waters. Higher sulphate of Mg concentrations, act as laxative to human being. Higher concentrations make the water unpalatable. It adds to the hardness to water. Mg concentration of the water samples ranges from 1.68-3.55 gm/L. This indicates good quality of water. Permissible Mg concentration is 50-150mg/L (WHO and ICMR).

Heavy/trace metals

The metals with density more than 5 times higher than that of water are known as heavy metals. They are present in traces in natural waters but many of them are toxic even at very low concentrations. Industrial waste and sewage disposed to the natural waters will increase their concentration. Some of the heavy metals in specified amounts are extremely essential to humans but little high concentration may cause serious physiological disorders. Malleswara Rao *et al.* have analysed natural fresh water of Andhra Pradesh for estimation of concentration of heavy metals for two seasons summer and monsoon and reported higher concentration of metals. Table 1(b) gives the variation of some of the trace metals in the water samples. Martin *et al.* (2000), have studied the bioaccumulation of trace/heavy metals at Tharangambad and Vanjur Esturaries. Iron is one of the most abundant elements of water and found in appreciable quantities in all kinds of waters. Fe has more solubility at acidic pH and hence large quantities of iron are leached out from the soils by acidic waters. Corrosion of pipes, pumps, etc., also will add to the concentration of Fe in water. The concentration of iron in the present water samples is in the range 0–270 ppb. The standard permissible limit for iron is up to 300 ppb (www.cpcb.nic.in/hpcreport/vol3k.htm). Manganese concentration measured was 0–40 ppb and standard permissible limit is 100 ppb.

The specified concentration limit for lead is 0.50 ppb. (www.cpcb.nic.in/hpcreport/vol3k.htm). The water samples recorded high lead contents ranging from 10–60 ppb that seems to be of much concern. The probable reason for the higher lead may be exclusively from the combustion of gasoline containing Pb antiknock additives (Eisenreich, 1980). The concentrations of zinc are within the limits, that is 0–340ppb. The standard concen-tration of zinc is 5000 ppb (www.cpcb.nic.in/hpcreport/vol3k.htm). Concentration of Cu in the present water samples varied between 0-50 ppb.

CONCLUSION

1. The value of pH in all the water samples are found to be neutral to alkaline due to

the presence of bicarbonate, which undergo hydrolysis in soil which is seen in high values (140-270mg/L).

2. Electric conductivity is found to be in the range 0.007-1.84 μ mhos.

3. Concentration of calcium is higher in the water samples (32-172 mg/L), which may be due to the leaching out of rocks.

4. Water samples have higher potassium concentration that can be attributed to the rock weathering in the area.

5. Water samples are rich in lead content that can be due to the combustion of gasoline containing Pb antiknock additives.

Therefore, necessary water treatment is recommended before using the ground water around Ramnadi basin for drinking purpose. Due to the growing urbanization and population, a natural resource of water, Ramnadi is getting exploited. All the domestic sewage and industrial effluents are being dumped into the river. Human activities, like washing cloths with detergents have caused the eutrophication of the river.

Increasing urbanization has led to the industrialization and created chain of environmental problems in the Ramnadi basin. Ramnadi basin is under stress of water pollution. Sedimentation in the river has brought water-storing capacity down. Urbanisation is considered as a part of development process but if it is unplanned it creates shortages of housing, shelter, basic health services, sanitation, clean air, drinking water, education, transport, energy, etc. Urbanisation has disturbed ground water management and brought in its wake, a series of problems, like congestion, insanitation, and mushroom growth of slums leading to environmental degradation. Urbanisation has lead to the construction of the cities that in turn created their own environments and exerted powerful impacts on the atmosphere and climate. Materials used in the construction work of cities have disturbed the absorption and reflection processes affecting the precipitation patterns. Therefore, massive programs of sustainable development can help to control the degradation of the environment.

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