Assessment of anthropogenic impacts on groundwater quality in coastal Goa

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Abstract :
A complex and interrelated series of modifications to natural water quality is created by the diversity of human activities impinging on the hydrologic cycle.It is well recognized that the quality is just as important as its quantity.Pollution can impair the use of water and can create hazards to public health and environment through toxicity and diseases. Among several human activities urbanization is one which can adversely affect both surface water as well as groundwater quality. In the present study an attempt has been made to assess the ground water quality in an area extensively urbanized and lies in close proximity to the sea coast in Goa. Twenty five groundwater samples have been collected for bacterial analysis from the shallow unconfined aquifer in the study area. TDS, pH EC and temperatures have been measured in the field in 100 groundwater level monitoring wells. The bacterial analyses have indicated severe groundwater contaminations by Coliform bacteria. The two main reasons for bacterial contamination of shallow groundwater are assessed to be reckless disposal of urban liquid wastes and cattle wastes. The aquifer is made up of highly permeable sandy loam having very shallow water table conditions and hence is highly vulnerable to contaminations. The lack of sewage collection system has adversely affected the groundwater quality in the area.
Key words: Bacteria, contamination, urbanization

Introduction :

A complex and interrelated series of modifications to natural water quality is created by the diversity of human activities impinging on the hydrologic cycle.It is well recognized that the quality is just as important as its quantity.Pollution can impair the use of water and can create hazards to public health and environment through toxicity and diseases. Among several human activities urbanization is one which can adversely affect both surface water as well as groundwater quality. In the present study an attempt has been made to assess the ground water quality in an area extensively urbanized and lies in close proximity to the sea coast in Goa. The main objective is to get first hand information of the groundwater quality status so that the possible sources of water contamination can be detected for remediation.

The area is covered by shallow unconfined sandy and lateritic aquifer and water table depths are very shallow and lot of people depend on the shallow groundwater for their daily needs. It is feared that the urbanization could have affected the groundwater quality in the area. Therefore it is indented in this study to get first hand information of the groundwater quality status so that the possible sources of water contamination can be detected for remediation.

The present study area falls in south Goa located along the Arabian Sea coast. The area is covered in toposheet no 48E15-SE of 1:25000 scale, having an area of 41 km^2. The villages that fall in the area include Consu, Velsau, Cansaulim, Arrosim, Majorda, Utorda, Betalbatim, Colva, and Benaulim from north to south. These villages are quite different from villages of rest of the country as these have all the infrastructure and other facilities of a town.

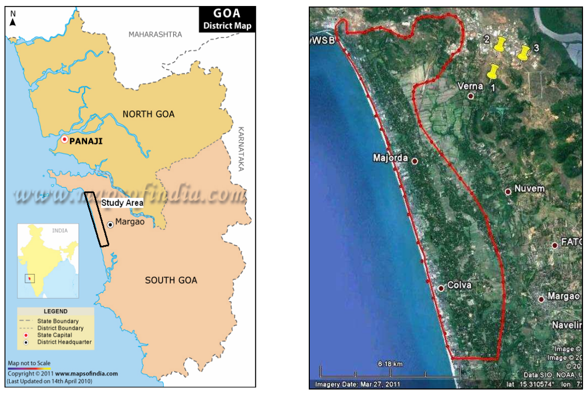

Fig 1 : Location map of the study area; water shed boundary is shown on google image

The study area is generally plain except in the northern part where a lateritic plateau exist at about 60 to 80m above msl. rest of the area is just 5m to 20m above msl. In order to visualize the topography three dimensional models have been prepared first using the ground elevations from survey of India topographic map and then using elevations derived from the latest Google image. The 3D terrain maps so prepared are given in Fig.2A &B. It is seen from the comparison of then terrain maps that the one derived from the Google image data is more close to the field observation. The area is covered mainly by loose sandy loam and at places lateritic rocks. the sand is mainly windblown and some of the sand dunes are stabilised and have plantations on them. The major part of the area is covered by settlements and in the low lying valley plains paddy cultivation is extensively practiced. the population density is high in the area. The land use map is shown in Fig. 2B.

Monthly rainfall data from Madgaoraingauge station located close to the study area has been collected from 2006 to 2010 period. The plot of the rainfall variation is shown in Fig.3.The rainfall variation in the area from 2006 to 07 it increased by 12% followed by about 17% decrease during 2007 to 08. However, from 2008 to 09 and 2009 to 10 the rainfall increased by 9% and 18% respectively. In 2006 the rainfall started in May and it increased in June. During 2008 the rainfall started in June but decreased in July. During 2009 also the rains started in June but increased in July. Considerable and abnormal fall in rainfall during August 2009 is reflected in the plot. There was sizable rainfall during October and November of 2009 and 2010. This late rainfall is useful in groundwater recharge and maintenance of water levels. As seen from the above figures the rainfall during the period of record has increased to some extent steadily except during the year 2008.

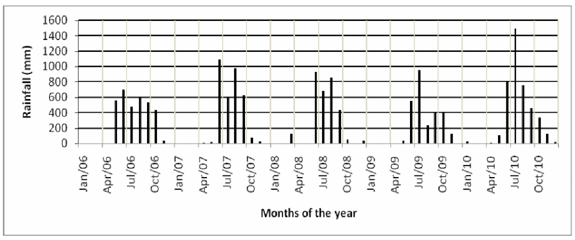

Fig. 3: Monthly rainfall variations at Madgao rain gauge station, Goa

Material And Methods :

The required base map of the area was prepared from the Survey of India toposheet and then this was marked on the Google image to derive the surface elevations. The groundwater sample points were identified at 25 locations based on local land use pattern and availability of the existing open well. Groundwater samples were collected from each of these well and subjected to bacteriological analysis. The TDS, Ec, pH and temperatures of the water were measured in the field using portable instruments. All care was taken to handle the sample to avoid contamination and standard procedures were followed for the analysis. The location details of the water sampling points and the data analysed are given in Table 1. The 25 well locations used for bacteriological sampling are plotted in **Fig.4.** The pH, TDS, Ec and temperatures were measured in all the 100 groundwater level monitoring wells in the study area.

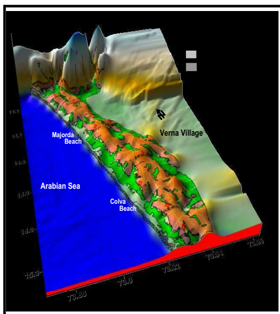

Fig.2A: Terrain Map generated using ground elevations sampled from google image

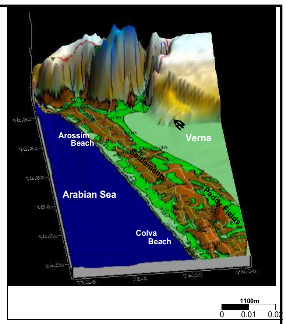

Fig.2B: Terrain Map generated using ground elevations digitized from topographic map of 5m contour interval

Results and Discussions :

The water quality data collected from the field and analysed in the laboratory are used in assessing the status of the groundwater quality in the study area. The Total Dissolved Solids (TDS) represent the total mineralisation of the water. As seen from the data the TDS concentrations of groundwater are moderate generally around 100 ppm indicating low dissolved minerals. The spatial distribution of the TDS values measured are shown in Fig. 5. It is seen from the map that the TDS values are well within the prescribed limits for drinking water (1000ppm) and even close to the coast the TDFS does not increase showing no impact of sea water intrusion. The pH of groundwater is generally seen to be less than neutral. The pH distribution map is shown in Fig. 6. It is seen from the figure that more acidic waters are present in northern parts around Vasao and Konsua villages. Therefore water are corrosive in nature.

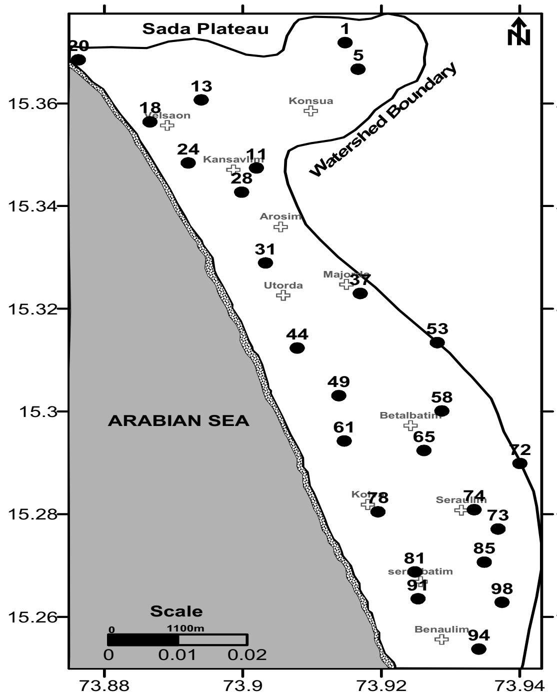

Fig.4. Location of groundwater sampling points

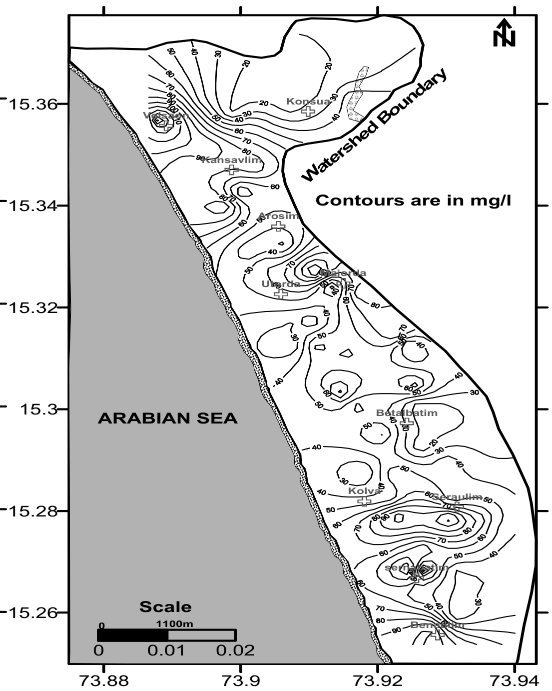

Fig.5: TDS distribution map measured during May 2012

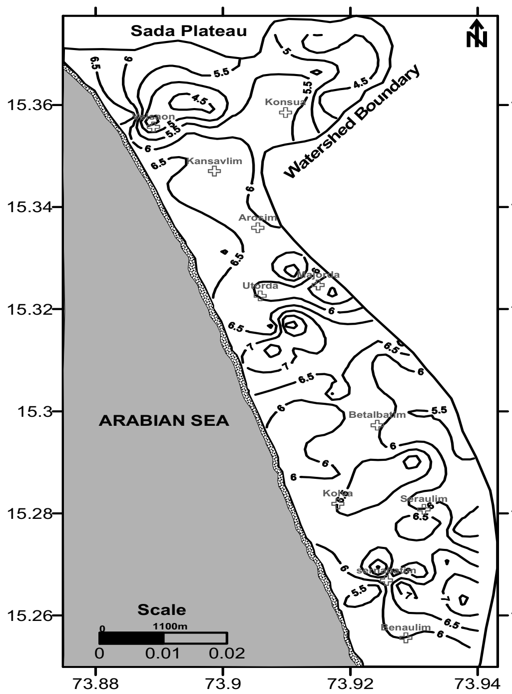

Fig:6: Variation of pH of groundwater during May 2012

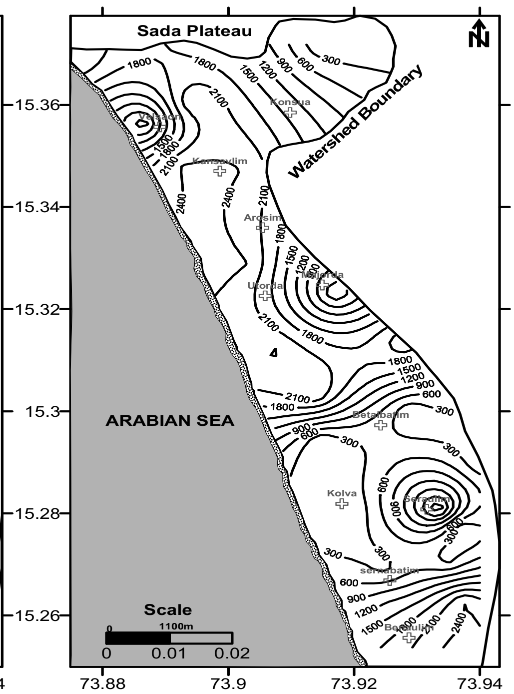

Fig: 7: Variation of Coliform bacteria in groundwater during May 2012

S.no	Well no	Location	Latitude	Longitude	E-Coli no/100ml
1	1	Towsarvaddo,Consua	15° 22' 19"	73° 54' 53"	39
2	5	Pimple vaddo,Nagoa	15° 22' 00"	73° 55' 00"	460
3	11	Madalem,Cansaulim	15° 20' 51"	73° 54' 07"	2400
4	13	Murdi,kuelim	15° 21' 38"	73° 53' 38"	2400
5	18	Velsao	15° 21' 23"	73° 53' 12"	93
6	20	Velsao	15° 22' 07"	73° 52' 35"	2400
7	24	Primeirovado	15° 20' 54"	73° 53' 32"	2400
8	28	TontemCansaulim	15° 20' 34"	73° 53' 59"	2400
9	31	Bandar Arossim	15° 19' 44"	73° 54' 12"	2400
10	37	Utorda	15° 19' 23"	73° 55' 01"	23
11	44	Pachecovaddo	15° 18' 45"	73° 54' 28"	2400
12	49	Ranvaddo	15° 18' 11"	73° 54' 50"	2400
13	53	Godinhovaddo	15° 18' 48"	73° 55' 41"	2400
14	58	Hapot	15° 18' 05"	73° 55' 43"	39
15	61	Thondvaddo	15° 17' 39"	73° 54' 53"	23
16	65	Nagvadobetalbatim	15° 17' 33"	73° 55' 34"	460
17	72	Seraulim	15° 17' 24"	73° 56' 24"	23
18	73	PovacaoBenaulim	15° 16' 38"	73° 56' 13"	64
19	74	Per seraulim	15° 16' 51"	73° 56' 30"	2400
20	78	4th ward colva	15° 16' 50"	73° 55' 10"	23
21	81	Copelvaddo	15° 16' 07"	73° 55' 30"	240
22	85	Cana benaulim	15° 16' 14"	73° 56' 06"	210
23	91	Ambeaxircolva	15° 15' 48"	73° 55' 31"	1100
24	94	ManzilvaddoBenaulim	15° 15' 14"	73° 56' 03"	2400
25	98	Grande pulvaddobenauli	15° 15' 46"	73° 56' 14"	2400

Table 1: Water sample locations and quality data

Conclusions :

From the study the following conclusions can be drawn

1. The pH of groundwater indicates that the shallow groundwater are slightly corrosive in nature
2. The groundwater are less mineralised in terms of total dissolved solids
3. The shallow groundwater is highly contaminated by Coliform bacteria and the reasons are both urbanization and unscientific cattle rearing in the area.
4. The shallow aquifer in the study area is highly vulnerable to contaminations and shallow groundwater is an important source for use and therefore it needs be taken care of.

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