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Review

Integration of Geochemical and Electrical Studies for Groundwater Quality in Parts of Hyderabad, A.P., India

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Abstract

In this paper an attempt is made to integrate the results of geo-electrical and geochemical studies and introduces the concept of IGQI which minimize the noise and enhance the signals over arising geochemical background. Integration of these methods are tested over the study areas (i) OU and surrounding area (ii) Katedan area will be combined with a view to critically analyzing the integration thus effected to traced the contaminated zones.

Based on the IGQI, some prominent zones are coincided with the contaminated zones i.e. Ramanthapuram, North of Musi river, Uppal, Peddacheruvu, Nacharam, Mallapur, RKPuram cheruvu and Nadimi cheruvu in study area I and Katedan IDA, APAU and Sivarampally in study area II.

Keywords: Integrated geochemical quality indicator (IGQI), Vertical Electrical Soundings(VES), Qualitative analysis

Introduction

Rapid urban sprawl and industrialization have the unfortunate fallout of environmental pollution. In the absence of appropriate waste management strategies, many human activities and their by-products have the potential to pollute surface and subsurface water. Industrial effluents, and wastes from urban infrastructure, agriculture, horticulture, transport and discharges from abandoned mines and deliberate or accidental pollution, all eventually affect the water quality. The pollutants from the stream may move slowly in to the ground, thus affecting the quality of groundwater.

The city of Hyderabad is a case in example; while there has been tremendous growth in terms of population, extent and land use profile, it has been mostly unplanned or ill-planned. Groundwater in large areas of the city is contaminated by domestic and industrial pollutants. This paper shows the extent of and degree of groundwater contamination in parts of Hyderabad.

Study area

Hyderabad, the capital of Andhra Pradesh, is located between latitude 17° 15′ N to 17°35′ N and longitude 78°20′ E to 78°37′E. It is the sixth largest city of India (2001). It is one of the fastest growing metropolises in terms of population, area and land use, and with its heterogeneous demographic profile, is cosmopolitan in its truest sense. The study area I located in the north eastern part of Hyderabad and covers OU campus , uppal and Nacharam industrial area, has an approximate extent of 40 sq kms and lies in Ranga Reddy district between latitudes 17°22′30″ N and 17°30′ N and longitudes 78°30′ E to 78° 37′E (Survey of India toposheet number 56K/11/NW). The study area II is located in the south western part of Hyderabad and covers Miralam, Katedan and surrounding industrial areas. It lies between latitudes 17°18' 45" N to 17°22' 30" N and longitudes 78°25' E to 78° 27' 30" E, covering an area of 30.59sqkm (Survey of India toposheet number 56K/7/SE).

Qualitative analysis of electrical data

Although indirect, the geophysical methods provide information an aquifer geometry that is useful in conceptualization of the aquifer system. Thus 137 vertical electrical soundings (VES) were carried out covering the entire study area I (80) and study area II(57) using the schlumberger method of electrode configuration. Figure 1 a& 1 b shows the location map of VES respectively.

Figure 1(a): VES location map of study area I

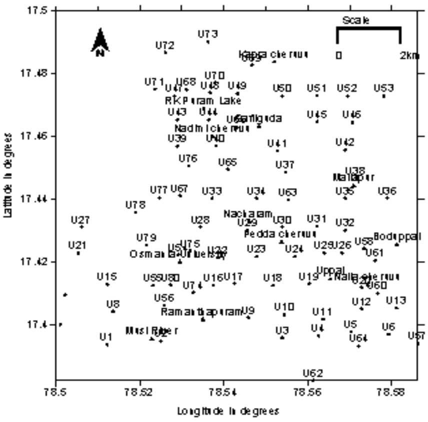
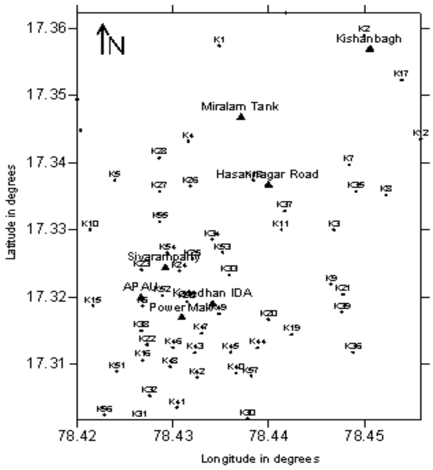


Figure 1(b): VES location map of study area II



Qualitative analysis of VES data are grid based geoelectrical surveys. The apparent resistivity maps prepared for AB/2 = 5m, 10m and 15m have apparently indicate the change in apparent resistivity vertical directions. This change is attributable, within small distances evidently indicates the change in electrical property variation from fraction of a ohm-meter (Ωm) to several thousands of ohm-meters. The resistivity of formation is mainly dependent on the degree of water saturation, amount of dissolved solids, content of organic matter and grain size. From a qualitative analysis of VES data. One can understand the hydrogeological process / or polluted zones taking place in the hydrogeological changes.

Study Area I

(a)AB/2 =5 m: Apparent resistivity map is presented by considering the apparent resistivities of all the stations for AB/2=5 m separation on the study area, iso-apparent resistivity contours map with an interval of 10 Ωm. It can be seen that , there is a good correlation of the salinity of the upper layer with resistivity (Figure 2a) and apparent resistivity map indicates that, northern part of RK Puram , Patel cheruvu, south of Musi river have broad resistivity lows. The apparent resistivity more than 30 Ωm at remaining parts

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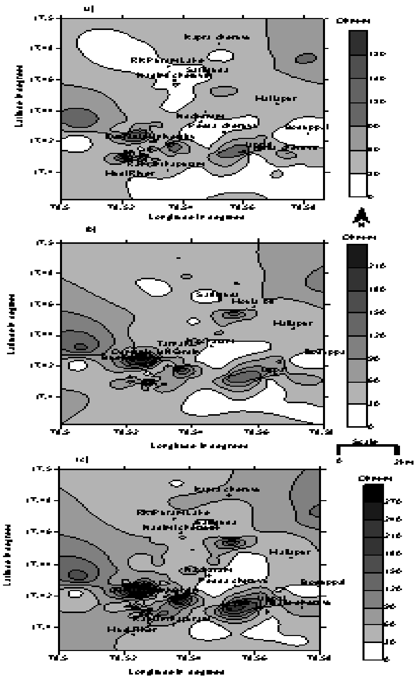
of the area. The low resistive zones may be attributed to polluted zones.

Figure 2: Contour maps of AB/2 configurations (a) 5m (b) 10m (c) 15m in the study area I



(b)AB/2 =10 m: Apparent resistivity map is prepared for the electrode separation of AB/2=10 m to know the vertical and horizontal extension of the polluted basement i.e. low resistivity zone. Keeping 10 Ωm contour intervals, shown in Figure 2b, lows indicated at RK Puram, Pedda cheruvu and south of Musi River and few isolated places.

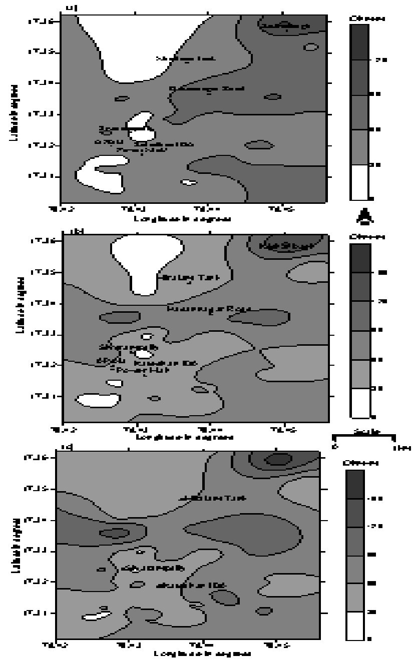
(c)AB/2 =15m: This map also prepare similar to AB/2=5,10m pattern, where as contour interval was kept 10 Ωm. The iso pach map (Figure 2c) of AB/2=15m, indicate the distribution of the apparent resistivity of the formation along lateral and horizontal directions. Low apparent resistivity values at RK Puram, Pedda cheruvu and few places at south of Musi river. This may be attributed to the clay or sandy clay. A high resistivity zone demarcate throughout the area.

Apparent resistivity (ρ_a) values are comparatively less in the previous map and are continued to the RK Puram, Pedda cheruvu and south of Musi River. It is evident that small patches of this low resistivity area all over.

Study Area II

(a) AB/2 =5m: Apparent resistivity map is constructed by plotting the apparent resistivities of all the stations for AB/2=5 m separation on the study area, iso-apparent resistivity contours interval of 10Ωm. From Figure 3(a), it can be seen that low resistivity values were observed at Sivarampally, southwest of Katedan IDA regions. The remaining area is followed by over 50-60Ωm.. The low resistive zones may be attributed towards water contamination up to vertically 5m depth.In the north-western parts also characterized by low, there is no adequate VES points, couldn't be describe.

Figure 3: Contour maps of AB/2 configurations (a) 5m (b) 10m (c) 15m in the study area II



(b)AB/2 =10m: Figure 3(b) shows contour map of isoresistivity for AB/2=10m. Lows indicated at Sivarampally, southwest of Katedan IDA regions. From fig it can be concluded that the contaminated zones are spread up.

(c)AB/2 =15m: This map also prepare similar to AB/2=5,10m pattern. The contour map (Figure 3(c)) of AB/2=15m, indicate the distribution of the apparent resistivity of the formation along lateral and horizontal directions. Low ρ_a values noticed at north Sivarampally, Sivarampally, southwest of Katedan IDA. Apparent resistivity ranges between100-250Ωm, exhibits for hard rock basement.

The resistivity of the weathered over burden at shallow depth upto 5-10mts, is vary due to degree of weathering, saturation and presence of contamination of water zones. Since the water table is shallow and weathered zone is largely saturated and any resistivity below 30 Ωm, indicating groundwater contamination in the absence of any clay material. Further, the quality of groundwater in the region has been affective negatively due to discharge of the effluents similar to the study area I.

Geochemical analysis

In the present investigations 171 groundwater samples from study area I comprising Osmania University, Nacharam, Mallapur and surrounding areas (Figure 4a) and 50 samples from study area II comprising Mir Alam, Katedan IDA and surrounding areas (Figure 4b) were collected from bore wells located in parts of the city during December 2007. The precise location (geographic coordinates-longitude and latitude) of the sampling points was determined in the field using GPS (Global Positioning System).

Figure 4(a): Location map of groundwater samples in the study area I

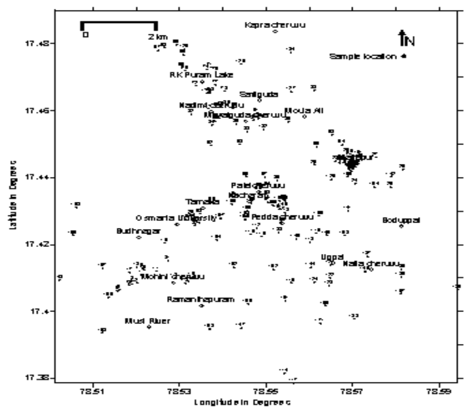
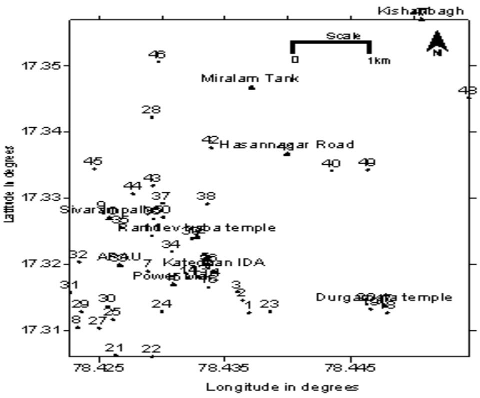


Figure 4(b): Location map of groundwater samples in the study area II



These samples were analyzed for constituents like pH, TDS, K^+, Na^+, Mg^{++}, Ca^{++}, F^-, Cl^-, SO_4^{--}, NO_3^-, HCO_3^- , TH and EC by standard methods in the geochemical laboratory of the National Geophysical Research Institute (NGRI), as per the standard procedure for American Public Health Association (Browen et al., 1974; APHA 1985 & 1998).

Table 1 & 2 summarizes the evaluated statistical parameters, namely minimum (Min), maximum (Max), mean and standard deviation (S.D) values for each of the measured constituents of the groundwater samples from study area I and II.

Table – I: Statistical Analysis of Groundwater Samples of Study area I

No	Parameter	Min	Max	Mean	S D
1	pH	6.2	8.65	7.54	0.440
2	EC (µS/cm)	222.9	5086.9	1898.4	868.02
3	TDS (mg/l)	29.9	2330	1044.53	421.55
4	Na^+ (mg/l)	2.5	455	122.8	80.3
	K^+ (mg/l)	0.2	28.4	6.8	4.39
6	Mg^{++} (mg/l)	10	525	93.5	98.8
7	Ca^{++} (mg/l)	16	860	192.9	149.78
8	Cl^- (mg/l)	30	1020.0	287.8	192.5
9	SO_4^{--} (mg/l)	14	361.2	111.6	68.97
10	HCO_3^-(mg/l)	30	622.2	275.5	144.6
11	NO_3^-(mg/l)	0.1	326.0	77.5	69.86
12	F^-(mg/l)	0.0	7.0	1.7	1.11
13	TH	117.9	3712.3	862.5	723.7

Table- 2: Statistical Analyses of Groundwater Samples of Study Area II

No	Parameter	Min	Max	Mean	S D
1	pH	6.7	8.4	7.36	0.3537
2	EC(µS/cm)	694.0	6922.0	2568	1203
3	TDS(mg/l)	428	4419	1548.443	770.19
4	Na^+(mg/l)	16	507.1	156.83	99.78
5	K^+(mg/l)	0.7	29	6.23	4.38
6	Mg^{++}(mg/l)	19	408	116.98	77.247
7	Ca^{++}(mg/l)	16	800	222.77	126.58
8	Cl^-(mg/l)	60	1450	486.30	278.08
9	SO_4^{--}(mg/l)	30	1300	350.10	279.14
10	HCO_3^-(mg/l)	40	722.85	260.328	173.63
11	NO_3^-(mg/l)	0	901	140.3	146.84
12	F^-(mg/l)	0.0	2.37	0.9016	0.730
13	TH	159	3276	1003	573

Integrated Geochemical Quality Indicator(IGQI)

Groundwater quality normally reflects s water rock interaction. However, groundwater is increasingly at risk of contamination from potentially polluting activities at the surface. While chemical analysis yields the physical and chemical composition of water. The water quality estimate of the quality of drinking water.

The concentrations of the ions are more than permissible limits for drinking purposes. Alkalies and weak acids dominate the hydro chemistry of the study areas. The pollution of groundwater is due to large scale discharge of industrial effluents and sewage water. Figure 5 and 6 showing the combined presentation of all analyzed elements presented for study areas I and II adopting the Integrated Geochemical Quality Indicator (IGQI) as follows.

Figure 5: Contour map of IGQI in study area I

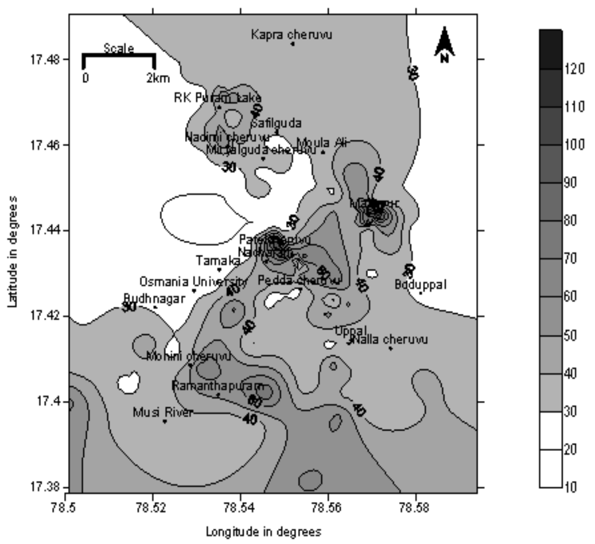
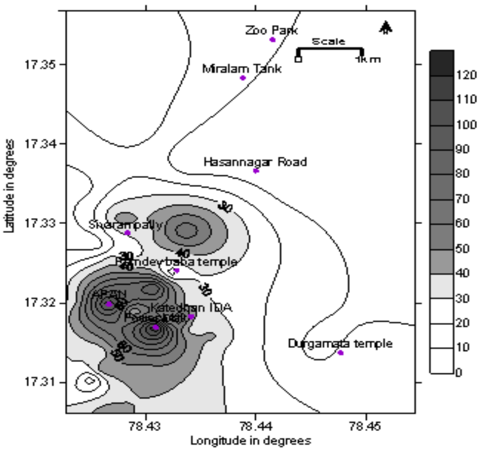


Figure 6: Contour map of IGQI in study area II



The integrated geochemical quality indicator (IGQI) which is a modified version of statistical correlation analysis. This allows to combined the geochemical analyzed elements data and helps in identifying the weak useful geochemical anomalies by suppressing the noises. The integrated geochemical quality indicator (IGQI), which is computed in a grid by suitable algebraic operations on the normalized observations obtained from geochemical elements. Normalization of observations is necessary to render them amenable for algebraic calculations and is as follows.

The representation of combined geochemical data the indicator contrast λ, the i^{th} Parameter measured any point is obtained by equation (Bhimasankaram, 1980; Ramadass and Vidyasagarachary, 1996),

$\lambda_{ij} = (a_{ij} - a_{ni})/S.D_i$ (1.1)

Where a_{ij} is the value of analyzed at j^{th} point and a_{ni} is normal or average value and $S.D_i$ is the standard deviation(S.D) of transforming parameter respectively. Calculating a_{ni} and standard deviation (S.D) for particular parameter of element the indicator contrast values are calculated, all the points are agreed. Then the function λ is complex parameter nature of the anomalies.

Such as taking absolute values of additions and generalized integrated geochemical quality indicator computed as

$\lambda_{IGQI} = |Ca + TDS + Cl + Mg + TH + Na + NO3 + SO4|$ (1.2)

This method is applied in two study areas in parts of Greater Hyderabad (i) Study area I (OU and around areas) (ii) Study area II (Katedan) shown in figure 5 and 6 respectively.

From Figure 5 & 6 integrated geochemical quality indicator was computing use equations 1.1 and 1.2. From this it is evident that λ_{IGQI} is three prominent peaks demarcating the high indicator zones are coincided with the contaminated zones. These are demarcated at Ramanthapuram, North of Musi River, Uppal, Peddacheruvu, Nacharam, Mallapur, RKPuram cheruvu, Nadimi cheruvu in study area I and Katedan IDA, APAU, Sivarampally in study area II.

The following important aspect obtaining IGQI approach of the two study areas as follows.

(i) All the analyzed elements should be normalized first.
(ii) The normalized values are taken as sum.
(iii) This method is highly useful for high concentrated zones for geochemical analysis in the noisy background and correlate with contamination.

Summary and Conclusions

The geo-electrical and geo-chemical indicator (IGQI) results were found to strongly correlate with each other. The major conclusions of integration carried out in study area I and II as follows.

1. Electrical profiling and VES soundings are surface to lateral litho variations and are thus useful to delineate of resistivity low represents which are contaminated zones in study area I and II
2. The resistivity values of AB/2 = 5,10 and 15m separation, the resistivity is less than 30 Ωm shows polluted/contaminated zones and further thought the horizontal distribution and vertical variation in the electrical characteristics of the subsurface.
3. These studies IGQI emphasize the necessity for regular monitoring of groundwater, which is not only a limited resource needing proper management, but also constitutes one of the important parameters for environmental impact assessment, especially in urban and industrial areas. The majority of the samples are influenced by discharge of industrial effluents and domestic sewage leading to deterioration in the quality of the resource. The contamination in the resource also poses a serious health hazard.
4. In particular, groundwater in the southern part of Study Area I appear to be highly polluted. Apart from that, areas such as Jamai Osmania, Nacharam and Mallapur are severely affected; anomalously high values on IGQI.
5. The Sivaramapally and Katedan areas of study area II appear to be particularly prone to groundwater pollution where anomalously high values of IGQI.
6. The pollution of surface and groundwater is arising in the investigated areas because of the industrial establishments and residential or human sewage which is traditional problem in human settlements, aggravated by urbanization and accelerated in course of modernization.

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