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Impact of Municipal Solid Waste on Groundwater in the Environs of Greater Visakhapatnam Municipal Corporation Area, Andhrapradesh, India

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ABSTRACT: The study deals with physico-chemical characteristics of groundwater in the environs of Greater Visakhapatnam Municipal Corporation (GVMC), Visakhapatnam district, Andhra Pradesh. The study area covering about 1143 km2 is famous for major industries, often called as Industrial City or Visakha Steel City. Haphazard urbanization, industrialization and improper disposal of solid wastes leading to contamination of groundwater, have been focused in this study. The improper and unscientific solid waste dumps in the unlined sewage drains drive pollutants into the groundwater regime which is an irrevocable loss and literally not possible to bring the quality of groundwater to its original state. In this study, about 25 groundwater samples were collected covering the entire area during August 2011. The water samples were analyzed to identify the parameters of physical, chemical and trace metals on the basis of APHA standard methodology. Trace metals of Al, Mn, Cu, Zn, Se, Rb, Cd, Pb and Co are in high content in areas like Akkireddypalem, Balacheruvu and Lankelapalem. These areas are in the vicinity of industries like Hindustan Zinc Ltd. and Visakha steel plant. Systematic work has not been carried out to discover the reasons for the accumulation of higher toxicants in these areas. The concentrations of physical, chemical parameters and trace metals in groundwater samples were compared with the Bureau of Indian Standards (BIS) and World Health Organization (WHO), and observed that the water quality parameters were exceeding the permissible limits in the villages of Balacheruvu, Akkireddypalem Sabbavaram, Tarluwada and Kapulauppada dump yard. During this study, it is observed that the higher content of different elements in groundwater is due to effluents, from industries and leachates from improper handling of urban solid wastes.

Keyword*: Physico-chemical analysis, trace metal analysis*

I. INTRODUCTION

Municipal solid waste is, discarded/rejected material typically being left-out from the different public sources. Investigations in study area revealed that, rapid growth in population during the recent decades resulted in increasing quantity of urban solid wastes. Municipal solid waste consists of day-to-day consumed and discarded items such as food wastes, containers, product packaging, and other miscellaneous like residential, commercial, institutional and industrial sources. The environmental problems existing in the urban areas of developing countries, municipal solid waste management and its impact on groundwater quality have been the most prominent in the recent years (Rajkumar et al., 2010).

The Greater Visakhapatnam Municipal Corporation (GVMC) is the second biggest municipal corporation in the state of Andhra Pradesh, India. Generation of municipal and industrial solid wastes increasing year after year is posing environmental challenges in this area. Most of the industries have their own mechanism for handling industrial solid waste. There are no major surface water bodies in the area and the dependable groundwater resources are being polluted at an alarming rate. Presently, groundwater quality is the major concern and therefore emerged as one of the most important environmental issues. Water demand for drinking and domestic purposes has been increasing due to change of life styles of people and demographic pressures (Swarna Latha et al., 2009). Hence, this study has been taken up to ascertain groundwater pollution hotspots in the environs of GVMC area. The industrial effluents of the Zinc smelter-Alum factory in Mindi Visakhapatnam, move in the direction of groundwater movement and flow towards marsh land through residential areas due to topographic control (Reddy and Rao, 1995).

II. STUDY AREA

The study area covering about 1143 km2 appears to be saucer shaped and lies in between 170 31' 42" - 170 55' 29'' Northern lat. and 83o 2' 5'' - 83o 25' 17'' Eastern long. (Fig.1). The altitude of Kailasagiri and Yarada konda hill ranges about 507 and 357 meters above msl respectively. The eastern side is surrounded by the Bay of Bengal. The area has been covered with deciduous forest around 33.33 km2, declining rapidly due to urbanization and industrialization (Jagadeeswara Rao, 2010). The study area is inhabitated with around 2 million populations besides major and other ancillary industries. As per 2001 census, the decennial growth rate of population in the area is around 22.44%. The high density of population is about 3670 km2 in urban areas whereas less density in rural areas. Solid waste generating from the urban environment is polluting water, soil and air, besides unhygienic surroundings. The municipal solid waste is being disposed at Kapulauppada, open sanitary landfill site for the last two decades. But the domestic wastes are dumped in unlined sewage drainages (rivulets) resulting in contamination of surface and groundwater. In rural environment, solid wastes are dumped in unlined sewage drains and abandoned dug wells, leading to groundwater pollution. In GVMC, industrial effluents and municipal solid waste dump results in groundwater pollution besides sea water intrusion (pollution) at places along the sea coast.

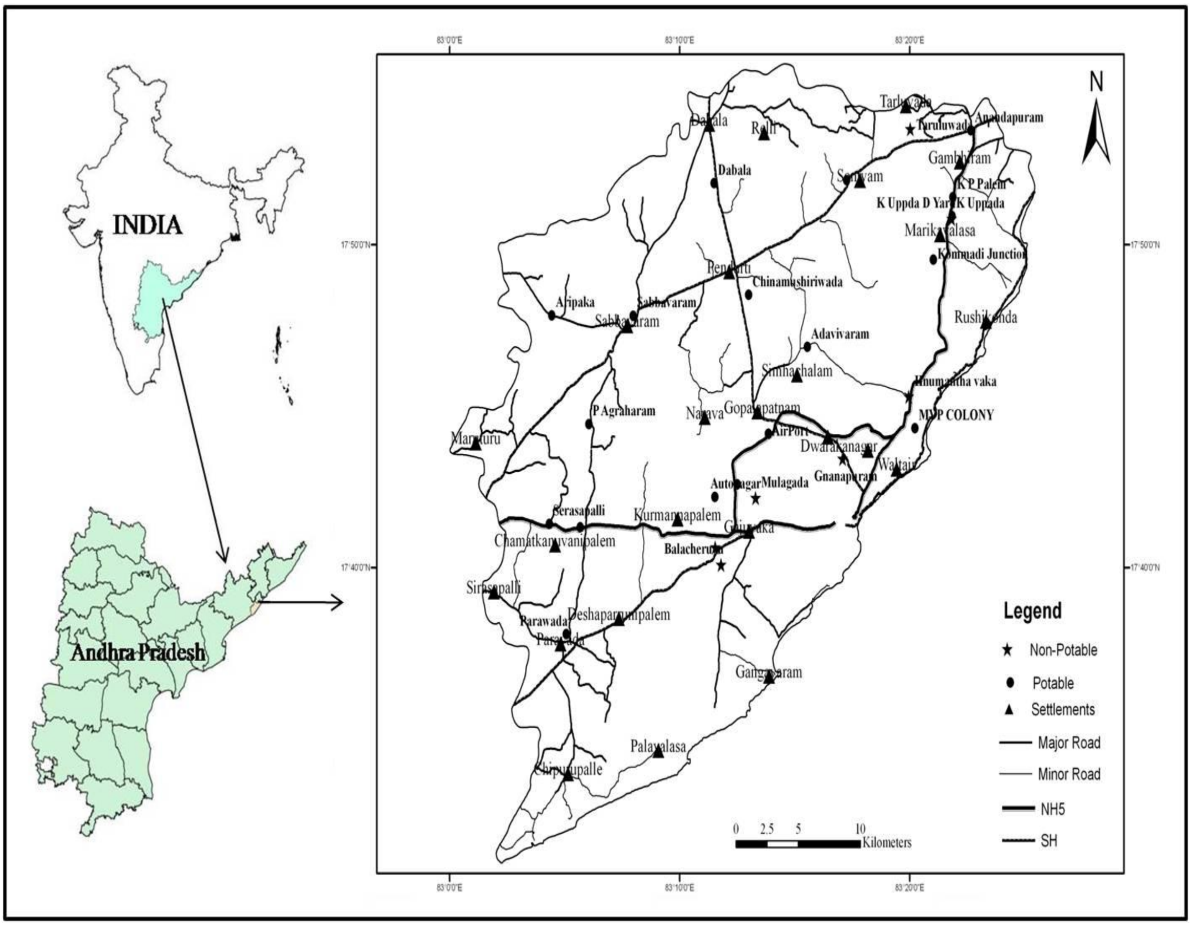

Figure 1: Location map of the study are

III. METHODOLOGY

In this study, about 25 water samples were collected adjacent to the unlined sewage drains (gedda) during August 2011 to analyze chemical parameters in laboratory following the guidelines of American Public Health Association (2005). The samples were analyzed for determining the concentrations of various chemical elements such as Na+, K+, Ca+, Mg2+, CO3-, NO3-, SO4-, Cl-, F-, and Fe. Samples were analyzed in laboratory using Flame Photometer for, Ca+ & Mg2+ elements, they were analysed by EDTA Titrimetric method. NO3-, PO4-3, Fe were analysed using UV Visible Spectrophotometer method (Shimabju, Japan), SO4- by Gravimetric method, F- by Orion Ion selective method, Cl- by Argentometric Method. All these procedures are part of APHA methodology for the examination of water and waste water. Trace metals of Al, Mn, Cu, Zn, Se, Rb, Cd, Pb and Co were analysed using the ICPMS (Inductively coupled plasma mass Spectrometer) Agilent -7700S.

IV. RESULTS

The chemical parameters obtained in this analyses revealing that the pH varies from 6.43 to 7.73 of alkaline nature within the permissible limits. The electrical conductivity (EC) values are in between 226 to 4237µs. The concentrations of Ca+, SO4-, F- and Cl- ions are observed closer to the maximum permissible limits in the villages of Sukkavanipalem and Kapulauppada. These villages are in low lying areas of Hindustan Zinc Ltd. and Kapulauppada sanitary landfill site respectively. The concentrations of TDS and TH and Na+, Mg2+, and Fe have exceeded maximum permissible limits in Kapulauppada and Sukkavanipalem. The higher contents in these villages could be seepage from the unlined sewage drain. These elements cause cardio vascular diseases which are reported in soft water areas. So far, no case has been reported regarding polluted groundwater in the area. The main source for sodium in groundwater resources is plagioclase feldspars, feldspathoids and clay minerals. Sodium content around 200 mg/l may be harmful to persons having cardiac and renal diseases and in women with toxemia associated with pregnancy (NAS, 1977). The concentration of sodium varies from 10 mg/l to 540 mg/l. Two samples found to be excess of Na+ than the maximum permissible limits in Kapulauppada and Sukkavanipalem. The calcium is a major constituent of most igneous, metamorphic and sedimentary rocks. The principal source of Ca+ in groundwater is members of the silicate mineral groups like plagioclase, pyroxene and amphibole among igneous and metamorphic rocks and limestone, dolomite and gypsum among sedimentary rocks. Disposal of sewage and industrial wastes are also important source of calcium. Concentrations upto 1800ppm has been found not to impair any physiological reaction in man (Lehr et al., 1980). The calcium ranges in between 16-160 mg/l. The magnesium concentrations in the study area varies from 5 mg/l to 136 mg/l. Kapulauppada and Mulagada samples are having excess content than the permissible limits in **(Table 1)**.

Table 1: Physical and Chemical parameters concentration in the study area (in ppm)

Parameters	M.V.P.Colony Sector-11	Hanumanthavaka Juntion	Kapula Uppada dumping yard	Kapula Uppada	Kottaparadesipalem	Anandapuram Junction	Taruluwada	Sontyam	Airport/ Kakaninagar	Auto Nagar	Sukkavanipalem/Mulagada	Gnanapuram	Gajuwaka M.R.Office	Parawada
Physical Parameters														
pH	7.73	7.62	7.047	7.05	7.166	6.992	6.607	7.204	7.451	6.75	7.643	7.747	7.764	6.430
EC	1.26	840.	2.072	3.16	2.069	500.5	462.2	1.206	1.431	1.587	4.237	815.6	2.102	226.7
TDS	690	490	1180	1840	1080	280	220	680	760	950	2840	460	1190	140
TH	390	240	540	790	460	150	120	370	440	460	860	250	520	88
BOD	0.80	1.30	28	3.0	1.90	0.50	BDL	< 0.4	1.0	2.9	2.6	0.9	0.20	BDL
COD	1.30	2.70	66	5.8	2.80	1.40	0.5	0.9	1.80	4.0	3.4	1.40	0.6	BDL
TA	460	268	590	860	500	160	140	450	480	580	980	300	580	90
Chemical Parameters														
Ca+	78	64	108	136	96	48	40	84	90	112	160	64	112	16
Mg2+	40	24	68	136	52	8	5	38	52	44	110	22	72	12
Na+	68	28	72	220	68	26	10	54	64	90	540	26	78	7.9
K +	0.16	0.24	1.30	2.70	1.190	0.780	0.590	0.128	0.164	0.290	3.40	0.30	0.98	0.10
HCO_3	280	164	360	524	305	98	84	274	268	280	524	160	317	28
Cl^-	140	68	230	450	146	50	26	114	158	166	880	56	260	18
F^-	0.89	0.81	1.540	1.76	0.880	0.760	0.811	0.960	1.140	1.340	1.940	0.790	1.120	0.680
NO_3^-	2.30	1.52	12.40	2.80	4.36	1.40	1.56	2.60	3.40	7.30	6.90	2.80	3.50	0.890
SO_4^-	48	36	96	150	10	20	18	40	54	104	298	34	104	10
PO_4^-	1.98	1.56	3.50	2.90	2.16	1.34	0.850	0.980	1.29	2.04	2.68	1.34	1.76	0.800
Fe	0.13	0.95	2.40	1.20	0.860	0.250	0.190	0.130	0.095	0.210	1.30	0.850	0.450	0.108

Iron is essential to all organisms and is present in the form of hemoglobin, but at higher levels they are toxic (Driscoll et al., 1994). Iron concentrations in the groundwater vary from 0.10 mg/l to 1.30 mg/l.

Kapulauppada landfill area, Kapulauppada village and Mulagada areas are having higher concentration. Chloride content of more than 250 mg/l makes the water salty; however, excessive chloride concentration affects the taste, but there is no known physiological hazard in the area. The chloride levels in natural water are an important consideration for the selection in public water supplies (Subramanian, 2000). Gajuwaka, Sukkavanipalem, Kapulauppada village and Kapulauppada dump yard site samples have higher chloride content. The fluorine is the most abundant element and is extensively distributed throughout nature (Kannan and Venkatesan, 1997). Fluoride plays a vital role in water quality management due to its adverse health effects. Fluoride also causes respiratory failure, hypotension and paralysis. Loss of weight, anorexia, anemia, wasting and cachexia are amongst the common findings in chronic fluoride poisoning (Jolly et al., 1973). The fluoride content in the study area ranges in between 0.68-1.94 mg/l. The villages which have higher fluoride content and exceeding the permissible limits are, Kapulauppada dump yard, Kapulauppada, Autonagar and Sukkavanipalem. Domestic sewages and industrial effluents, besides biological oxidation of reduced sulphur species, may add sulphate to water. Water with sulphate concentration upto 500 mg/l and above will be bitter taste (ICMR, 1975). The sulphate content in the area ranges from 10 to 298 mg/l. The higher contents of these elements in these villages could be leachates from the unlined sewage drains, dumping solid waste in an unscientific manner and also leachates from the solid waste dump yard at Kapulauppada site.

Dissolved metals in many instances are found at unnaturally higher concentrations because of industrial processes. In higher doses, these metals prove lethal to organisms, including humans. Trace metals, therefore, constitute a major category of elements having environmental significance. At higher levels they are toxic (DriScoll et al., 1994). One of the most important environmental issues today is groundwater contamination (Vodela et al., 1997) and wide diversity of contaminants affecting groundwater resources. Heavy metals receive particular concern considering their strong toxicity even at low concentrations (Marcovecchio et al., 2007). In the study area Al ranges from 3.87-30.17 (ppb) in Akkireddipalem, Balachervu, Dabala and Kommadi villages. Mn ranges from 0.91-82.46 in Balachervu, Adavivaram areas (Table 2). Cu ranges from 0.23-9.26 with an average of 2.455. Se ranges in between 0.41-3.49 with an average of 2.32 all the values are within the permissible limits. In our country, most of the groundwater is invariably polluted by industrial and domestic wastes. Zinc is one of the essential elements required for proper functioning of the body system (Raja and Venkatesan, 2010). Zn ranges from 0.98-93.24 with an average of 17.00 in Akkireddipalem, Sabavaram and Kommadi areas. The Ni can cause allergic reactions apart from being carcinogenic (McKenzie and Smythe, 1998).

Table 2: Trace metals concentration in the study area (in ppb).

Element Conc(ppb)	Akkireddy palem	Balacheruvu	Lankelapalem	Sirasapalli	P.Agaraharam	Sabbavaram	Aripaka	Dabala	C.Musirivada	Adavivaram	Kommadi Junction
Li	**4.6865**	**12.7009**	**3.2132**	**2.7827**	**2.8309**	**3.1624**	**6.0199**	**22.3095**	**1.6756**	**0.7612**	**2.1593**
Be	**0.0262**	**0.0249**	**0.0112**	**0.0114**	**0.0082**	**0.0314**	**0.0126**	**0.0119**	**0.0036**	**0.0232**	**0.0113**
Al	**21.8686**	**16.5071**	**12.8504**	**7.9687**	**7.2378**	**11.0253**	**5.7688**	**25.4381**	**3.87**	**7.9244**	**30.1742**
V	**10.6509**	**8.6762**	**4.6128**	**12.8017**	**12.7703**	**6.1377**	**13.4417**	**18.0371**	**17.8498**	**0.5881**	**19.3063**
Cr	**0.6483**	**0.9929**	**0.2511**	**0.8234**	**0.7796**	**0.1953**	**0.4076**	**6.1813**	**0.1781**	**0.2938**	**0.8687**
Mn	**3.8087**	**82.4662**	**25.634**	**1.0953**	**1.0282**	**3.3512**	**0.9187**	**2.1774**	**1.7481**	**68.5896**	**3.2527**
Fe	**6.6593**	**3.1847**	**4.9887**	**1.1503**	**1.3162**	**50.8322**	**6.3888**	**13.6237**	**4.9409**	**15.2144**	**24.0503**
Co	**0.1295**	**0.6045**	**0.1198**	**0.0811**	**0.0799**	**0.0653**	**0.0375**	**0.0083**	**0.0316**	**0.1316**	**0.0925**
Ni	**1.1483**	**1.7876**	**1.3284**	**0.3314**	**0.3923**	**1.5814**	**0.6138**	**0.7389**	**0.6198**	**1.2616**	**9199**
Cu	**4.2341**	**1.807**	**9.2657**	**1.3066**	**1.2753**	**0.9209**	**0.9624**	**2.7582**	**0.2394**	**1.1919**	**3.0488**
Zn	**16.0088**	**5.1183**	**31.106**	**0.9827**	**1.2736**	**93.2403**	**2.1705**	**2.9186**	**2.9791**	**12.0118**	**19.1619**
Ga	**28.4887**	**13.2323**	**22.6402**	**15.4477**	**15.3902**	**42.8038**	**19.0476**	**18.6544**	**4.1689**	**28.7126**	**10.1394**
As	**0.3978**	**0.7348**	**0.5024**	**2.4925**	**2.4631**	**0.2743**	**0.3617**	**4.1751**	**0.194**	**0.1332**	**1.2002**
Se	**2.0142**	**4.1593**	**1.0446**	**3.4924**	**3.4977**	**2.1019**	**2.9231**	**2.9163**	**0.4177**	**0.6286**	**2.3486**
Rb	**0.6294**	**4.1639**	**4.2427**	**6.5453**	**6.4872**	**2.6678**	**2.7927**	**5.5459**	**0.1251**	**0.7915**	**0.3311**
Sr	**1161.73**	**1691.80**	**725.260**	**559.104**	**549.409**	**1121.59**	**796.541**	**1043.88**	**370.231**	**398.503**	**338.078**
Ag	**0.0207**	**0.4337**	**0.095**	**0.0707**	**0.0523**	**0.0237**	**0.013**	**0**	**0.0123**	**0.0632**	**0.0843**
Cd	**0.033**	**0.019**	**0.0238**	**0.0034**	**0.0048**	**0.1494**	**0.006**	**0.0347**	**0.023**	**0.0156**	**0.0497**
Cs	**0.0071**	**0.0152**	**0.0138**	**0.0157**	**0.0164**	**0.0105**	**0.0102**	**0.0302**	**0.001**	**0.0053**	**0.0157**
Ba	**170.335**	**68.8955**	**138.360**	**92.4744**	**93.1887**	**266.72**	**121.313**	**115.283**	**27.6119**	**177.988**	**51.2905**
Tl	**0.0426**	**0.0613**	**0.0291**	**0.0232**	**0.0224**	**0.0161**	**0.0161**	**0.0182**	**0.0023**	**0.0081**	**0.0155**
Pb	**0.1648**	**0**	**0.5347**	**0**	**0.0504**	**0.3582**	**0.0535**	**0**	**0.1645**	**0.3095**	**1.2172**
U	**1.2551**	**13.269**	**1.0819**	**4.2614**	**4.2603**	**2.6185**	**1.9143**	**33.8515**	**0.2816**	**0.7861**	**4.3915**

Therefore, chemical monitoring of water sources become an essential part of water management. The measurements and characterization of these metals are necessary to understand their distribution and pathways in the ecosystem and to assess the impact of their discharge into environment (Johnels et al., 1967). The results of physical, chemical parameters and trace metals of groundwater have been compared with the Bureau of Indian standards-10500 (1991) and World Health Organization (1971 and 1983).

The area chosen for study is significant for industries, coastal environment and dense population. So far, no major studies have been carried out on solid waste interaction with groundwater. In this study, it is observed that the groundwater regime is being highly polluted due to improper dumping of solid waste in unlined sewage drains, besides geological causes.

REFERENCES

[1]. APHA, Standard methods for the examination of water and waste water. American Public Health Association, 21th ed., Washington (2005)

[2]. BIS, Indian Standard Drinking Water–Specification (BIS 10500: 1993). New Delhi, India.

[3]. Dasilva, Williams, R. J. and J.J.R.F., 'Interaction of the chemical elements with biological systems'. In; New trends in Bioinorganic chemistry (Eds) Academic press. London; 449-484 (1978)

[4]. Driscoll, C.T, Otten, J. K. and Iverfeldt, A., 'Trace metal speciation and cycling'; In Bedrich Moldan and Jiri Cerny (Eds): Scope 51, John Wiley and Son's. England. 299-318 (1994)

[5]. Indian Council of Medical Research. Manual of water quality for drinking water supplies, Special report 44, New Delhi (1975)

[6]. Jagadeeswara Rao, P, Satyanarayana, P.V.V, Venkateswara Rao, T, Harikrishna, P, Influence of Land use/Land cover on Groundwater in the Environs of Madhurawada Dome, Visakhapatnam District-A Remote Sensing Approach. Jour. Of Eastern Geog.Vol XVI (1):15-18 (2010)

[7]. Jolly, S.S, Bansal, B.C. and Mathur, C.C., 'Evaluation and Modification Fluoride Sampling and Analytical Methods', US Environmental Protection Agency, Washington, DC (1973)

[8]. Kannan, N. and Venkatesan, S., 'Fluoride contamination in drinking water in some areas of Aruppu kottai and Sivakasi taluks in Kamarajar district', India. Journal of Environmental protection, 17(7): 516-518 (1997)

[9]. Lehr, J. H., Gass, T. E., Pettyjohn, W. A. and DeMarre, J., ' *Domestic Water Treatment*',McGraw-Hill, New York. Linaweaver, Geyer, and wolff ... book, McGraw-Hill, New York (1980)

[10]. McKenzic, H.A. and Smythe, L.E., 'Quantitative trace analysis of biological', Elsevier, Amsterdam (1998)

[11]. Madhusudhan Reddy, P., and Subba Rao, N., 'Hydrogeoenvironment of industrial polluted zones in Visakhapatnam area', Andhra Pradesh, India. Journal of Environmental Hydrology, Vol.3, No.2 (http://hydroweb.com/jeh_3_2/andhra.html), (1995)

[12]. Marcovecchio, J.E., Botte, S.E. and Freije, R.H., 'Heavy Metals, Major Metals, Trace Elements'. In: Handbook of Water Analysis. L.M. Nollet, (Ed.). 2nd Edn. London: CRC Press:275-311 (2007)

[13]. NAS.' Water quality criteria'. Nat. Academic sciences. 23(1972):105 (1977)

[14]. Raja, G. and Venkatesan, P., 'Assessment of Groundwater pollution and its impact in and around Punnam area of Karur district', Tamilnadu, India. E journal of Chemistry, Vol.7, No.2: 473-478 (2010)

[15]. Rajkumar, N., Subramani, T. and Elango, L., 'Ground water contamination due to municipal solid waste disposal-A GIS based study in Erode city'. International journal of environmental sciences Vol 1, No1:39-55 (2010)

[16]. Subramanian, V., 'Water: Quantity-Quality perspective in South Asia', Kingston International Publishers, Surrey, United Kingdom. 256, (2000)

[17]. Swarna Latha. P., Nageswara Rao, K., Jaganadha Rao, M. and Hari Krishna, M., 'Physico-chemical characterstics of ground water in Greater Visakhapatnam Muncipal Corporation (GVMC)', Andhra Pradesh, Indian Journal of Environmental Protection, Vol. 29, No.5: 399-406 (2009)

[18]. Vodela, J.K., Renden, J.A., Lenz, S.D., Mchel Henney, W.H. and Kemppainen, B.W., 'Drinking water contaminants'. Poult. Sci., 76:1474-1492 (1997)

[19]. WHO, 'International standards for drinking water', World Health Organization, Geneva (1971)