IMPACT OF URBANISATION ON GROUND WATER REGIME IN VISAKHAPATNAM URBAN AREA, ANDHRA PRADESH, INDIA

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ABSTRACT

Visakhapatnam, one of the fastest growing cities in the country has witnessed large-scale industrialisation and urbanisation during the last four decades. With the estimated population of 13 lakhs in Visakhapatnam Urban Area (VUA) and a large number of industries, the water demands have increased drastically. The attempts to meet the water demands through surface water sources have not been commensurate with requirements and there is considerable gap between Municipal water supply and demand. As a result there is a stress on ground water. With the urbanisation processes, ground water recharge is also affected greatly. Added to these, the increased industrialisation and urbanisation coupled with lack of environment protection measures have led to deterioration of ground water quality.

1.0 INTRODUCTION

Visakhapatnam, located midway, between Calcutta and Chennai on East Coast of India is one of the fastest growing cities with a natural harbour. It has attracted large-scale industrialisation and urbanisation during the last four decades. As a result water demands have increased drastically. The attempts to meet the demands have not been commensurate with the water requirements. The principle sources of water to Visakhapatnam are located outside the city limits and are not able to meet the demands. The ground water plays a key role in bridging the gap between supply and demand. The increased industrialisation and urbanisation with insufficient environmental protection measures had impact on ground water.

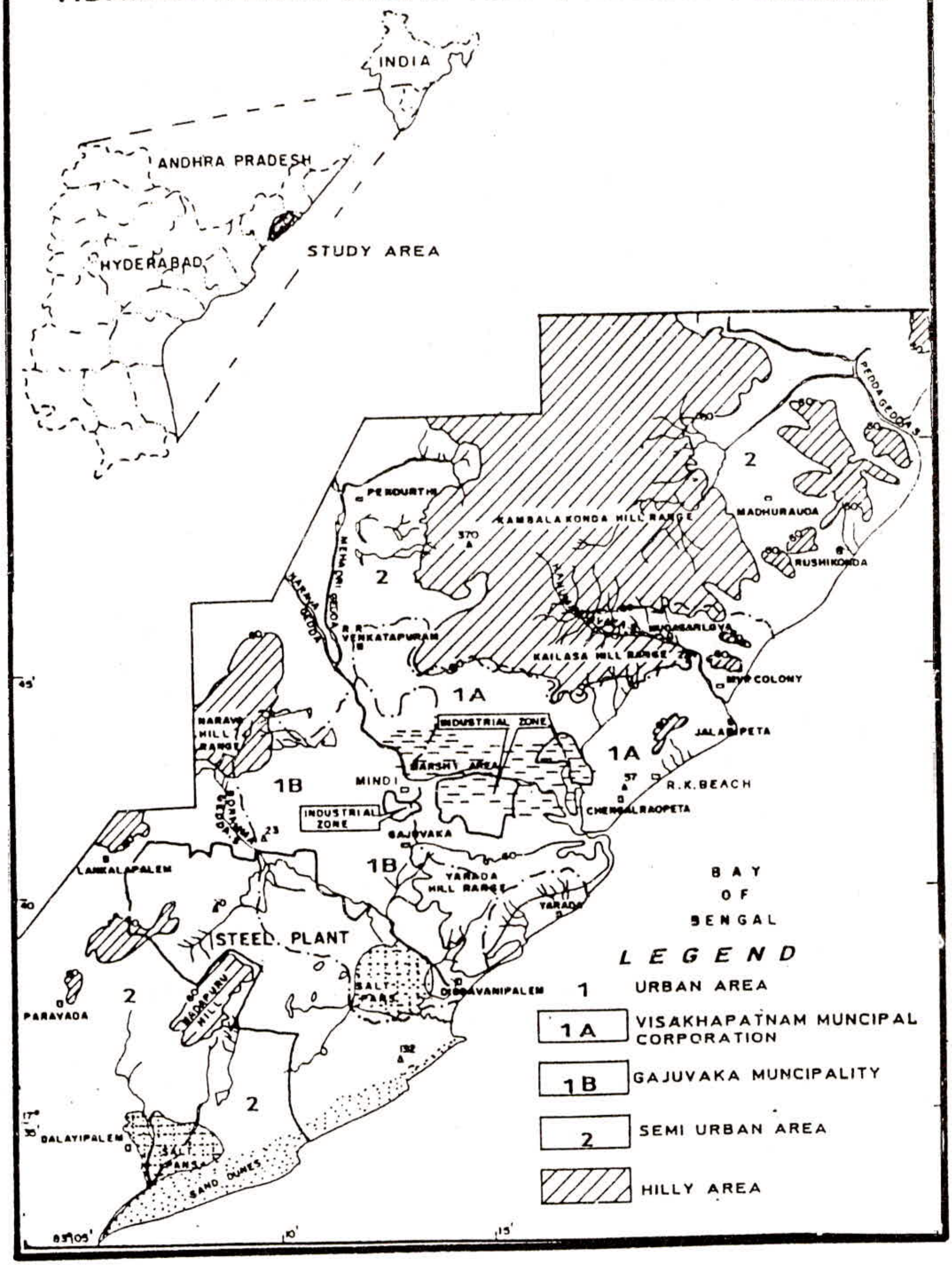
The study area includes urban area comprising Visakhapatnam Municipal Corporation (VMC) covering 111 Sq. Km and adjoining Gajuvaka Municipality (GM) covering 97 Sq.Km, while the remaining area is semi urban. It is located in the northeastern corner of Andhra Pradesh and is located between 17°32' and 17°53'; 83°05' and 83°27' covering an area of about 750 sq km (fig 1). It is included in Survey of India toposheet Nos. 65 0/1,2, 5&6.

The VUA is mainly drained by Hanumanthavaka, Naravagedda, Pedagedda, Borammagedda streams and other independent streams taking their origin in the adjoining hills and join Bay of Bengal, with a general slope towards south east. The general range of elevation in plains varies between 20 and

FIG.:-1

STUDY AREA

VISAKHAPATNAM URBAN AREA, ANDHRA PRADESH.



60 m, while in low lands, the elevation is less than 20 m. The important geomorphic units are hills, pediment, mud flats, coastal plain, colluvial plain and alluvial plain. The mean annual rainfall is 982 mm, of which south west monsoon contributes about 65% of total rainfall.

The area forms a part of Eastern Ghats tectonic complex of Archaean age which include khondalites, charnockite and migmatite groups. These are overlain by laterites of Sub-Recent age. The unconsolidated sediments of Recent age comprising red sediments, stream borne alluvium, colluvium and coastal sands also occur.

Ground water occurs under water table conditions in weathered residuum and semi-confined to confined conditions in deeper fracture zones. The mode of ground water abstraction is mostly by means of dug wells or shallow borewells. The dug wells range in depth from 2 to 21 m, while the general depth being 8 to 10 m. The depth of borewells varies from 15 to 60 m. The depth to water level range from 0.7 to 19.20 m. The hydrogeology map is shown as Fig.2.

2.0 URBANISATION EFFECTS

The urbanisation effects on ground water resource are as follows: (1) Rapid growth in population and consequent increase in water demands and thrust on ground water resource, (2) Industrialisation and consequence increase in water demands, (3) Increase in runoff and reduction in ground water recharge and (4) Ground water pollution.

2.1 Rapid Growth in Population and Consequent Increase in Water Demands and Thrust on Ground Water Resource

Visakhapatnam, the district headquarter has experienced rapid strides in its population growth from decade to decade. There has been four-fold increase in population during the period 1961-91. The population of VMC as on 1991 was 8,22,000 and it is projected to reach 12 lakhs by 2001. In the adjoining Gajuvaka Municipality, which was formed in 1990, there was a phenomenal growth in rate of population, with the commencement of steel plant. The projected population is estimated to be 2.5 lakhs by 2001. Thus the VUA comprising VMC and GM is having estimated population of 13 lakhs as on 1998 with decennial growth rate of 40% in VMC and more than 60% in Gajuvaka area during 1981-91.

As per National Building Code (IS 1172) a minimum of 135 litres per capita per day (LPCD) is to be provided for domestic purposes when the population is below 50,000 and 180 LPCD if the population is more than 50,000. In VMC as on 1998, the water requirement is worked out to be 145.35 MLD @ 135 LPCD requirement and 193.5 MLD @ 180 LPCD requirement, where as the per capita supply is only 83.7 LPCD (Table 1). Thus the deficit in water supply is to the tune of 42% @ 135 LPCD and 57% @ 180 LPCD. The principle source of water supply to VMC is surface water from reservoirs located outside the city limits. As such there is a lot of thrust on the only alternative source i.e ground water. Obviously, the deficit in demand and supply is met through ground water. About 1,13,000 dwelling units exist in the city excluding unauthorised constructions. As per VMC,

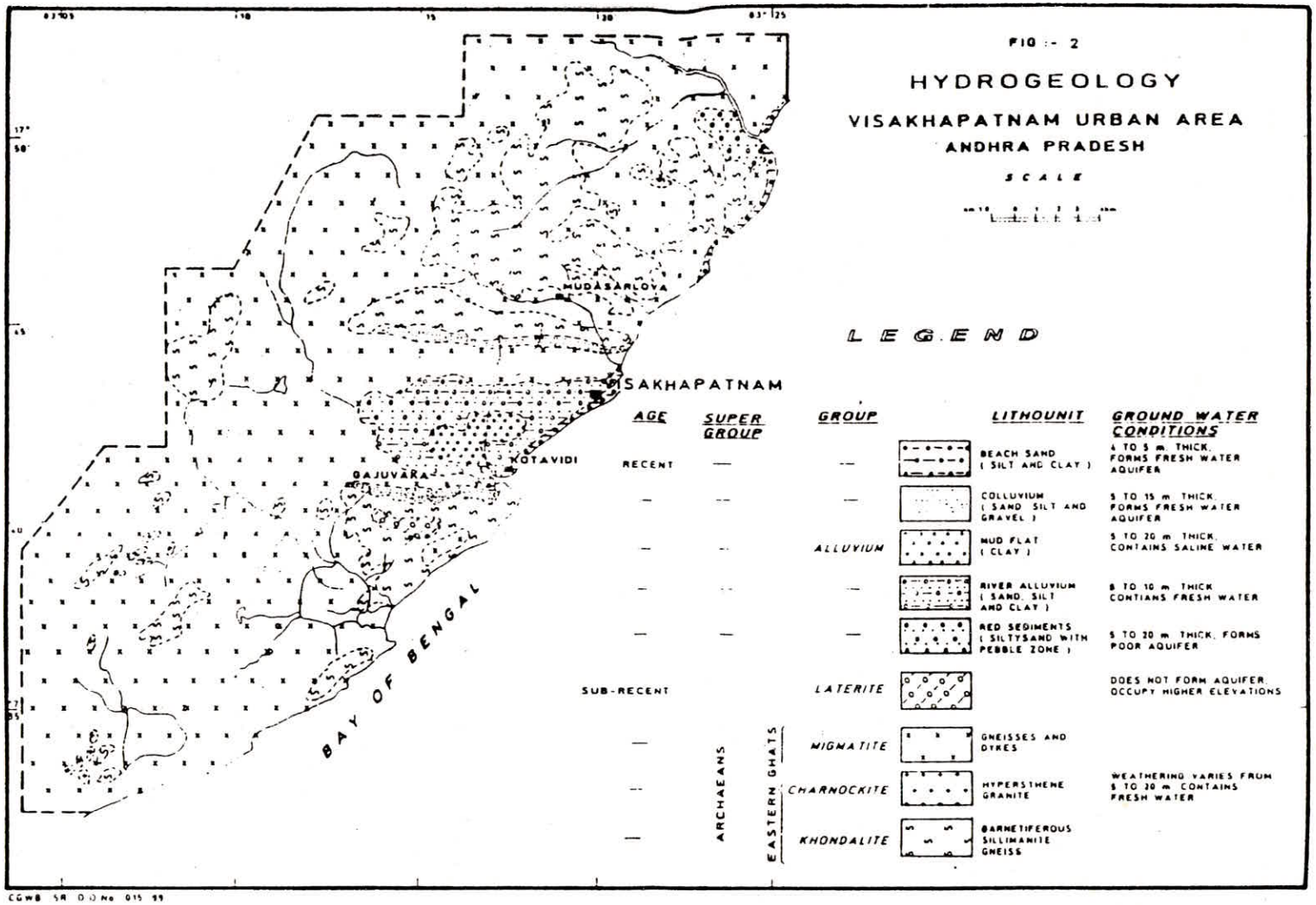


FIG :- 2
HYDROGEOLOGY
VISAKHAPATNAM URBAN AREA
ANDHRA PRADESH
SCALE
LEGEND
MUDASARLOVA
VISAKHAPATNAM
KOTAVIDI
GAJUVARA
BAY OF BENGAL
AGE
SUPER GROUP
GROUP
LITHOUNIT
GROUND WATER CONDITIONS
RECENT
SUB-RECENT
ARCHAEANS
EASTERN GHATS
ALLUVIUM
LATERITE
MIGMATITE
CHARNOCKITE
KHONDALITE
BEACH SAND (SILT AND CLAY)
4 TO 5 m. THICK, FORMS FRESH WATER AQUIFER
COLLUVIUM (SAND SILT AND GRAVEL)
5 TO 15 m. THICK, FORMS FRESH WATER AQUIFER
MUD FLAT (CLAY)
5 TO 20 m. THICK, CONTAINS SALINE WATER
RIVER ALLUVIUM (SAND, SILT AND CLAY)
8 TO 10 m. THICK CONTIANS FRESH WATER
RED SEDIMENTS (SILTYSAND WITH PEBBLE ZONE)
5 TO 20 m. THICK, FORMS POOR AQUIFER
DOES NOT FORM AQUIFER, OCCUPY HIGHER ELEVATIONS
GNEISSES AND DYKES
HYPERSTHENE GRANITE
WEATHERING VARIES FROM 5 TO 20 m. CONTAINS FRESH WATER
GARNETIFEROUS SILLIMANITE GNEISS
CGWB SR D.D.No 015 99

about 36% of households are supplied with surface water and public taps are used by 35% of households. Thus, 30% of households do not have access to surface water. It is presumed that these households are dependent only on ground water. Apart from this about 40% of households, having MCV water connection, also contain wells to augment the demands for domestic water purpose. As such the number of wells owned by private individuals is worked to be 44,000. The average ground water draft of each of the well is assessed to be 560 LPD and the total draft is computed to be about 25 MLD. Similarly the total draft from the wells drilled by VMC is computed to be 20 MLD. Thus the total ground water draft from all ground water abstraction structures is arrived at 45 MLD which comes to 16.21 MCM. It is estimated that ground water recharge and draft are roughly equal in VMC.

In Gajuvaka municipality, no comprehensive water supply scheme is existing and people are highly dependent on ground water. The per capita supply works out to be 14.53 LPCD only covering 18% of population. Thus the deficit in water supply is so high and works out to be 89% @ 135 LPCD and 92% @ 180 LPCD. So obviously the huge gap of demand and supply is met through ground water. Though reliable well census is not available, most of the households do have wells to meet their requirements.

Table 1: Domestic Water Demand Vis-à-vis Water Supply

S. No	Visakhapatnam Municipal Corporation						Gajuvaka Municipality				
	Year	Population (In Lakhs)	Water Requirement (MLD)		Water Supply (MLD)	Per-capita Supply (LPCD)	Popu-lation (In Lakhs)	Water Requirement (MLD)		Water Supply (MLD)	Per capita Supply (LPCD)
			@135 LPCD	@180 LPCD				@135 LPCD	@180 LPCD		
1	1981	5.84	78.8	105.1	36.0	61.06	---	---	---	---	---
2	1991	8.22	110.9	147.9	45.0	54.72	1.79	24.16	32.22	---	---
3	1998	10.75	145.1	193.5	90.0	83.7	2.32	31.32	38.75	3.37	14.53
Projected											
4	2001	11.50	155.2	207.0	---	---	2.50	33.75	45.0	---	---
5	2111	16.10	217.3	289.8	---	---	4.02	54.27	72.36	---	---

2.2 Industrialisation and Consequent Increase in Water Demands

Until mid sixties, the development in the city is confined to VMC limits. Subsequently considerable industrial development took place in the adjoining areas of Gajuwaka on the west and Gopalapatnam-Pendurthi in the north. The city has emerged as important industrial center of Andhra Pradesh. An integrated steel plant with a capital investment of 8,500 crores is situated in the Gajuvaka area. The other prominent industries in VUA include Hindusthan Zinc Limited, Bharat Heavy Plates and Vessels, LG Polymers, Hindusthan Shipyard and a number of Petro-Chemical industries. Apart from these, hundreds of ancillary industries are functioning. It is significant to note that while services alone represented the functional character of the city till 1961, the industry and transport became significant by 1971. Consequently, water requirements have grown up considerably. Though the demands of industrial requirements are not available, it is estimated that

the non-domestic water represents 50% of total consumption at present. The demand under this category is about 135-160 MLD. This excludes water demands of steel plant, which is about 315 MLD. The major and medium industries are consuming lions share of available surface water supply in urban area. However, the small-scale industries are depending on ground water. The total water demand by the year 2011 is expected to touch 450 MLD and as such there is likely to be more stress on ground water.

2.3 Increase in Runoff and Reduction in Ground Water Recharge

During the process of urbanisation, vast changes have taken place in the land utilisation pattern. Most of the land in urban area was converted to concrete buildings, roads etc. Small water bodies have disappeared. At places hill slopes have been occupied hindering the natural processes. As a consequence of all these human activities, the natural environment has greatly been affected. Due to construction of buildings for housing, commercial purposes, laying of asphalt roads for transport, the upper layer becomes impermeable resulting in reduction of ground water recharge and enhancement of surface runoff.

In VMC, ¼ of the area is under residential purposes, while 8% is under industry. Institutions and railways occupy about 6% each. Hills and forests occupy 10% of area while water bodies form only 1%. Port area constitutes 38%. However most of which is marshy in nature. As such the urban area suffers from open areas for rain water infiltration. With the reduction in open soil-surface area and increase in runoff, ground water recharge is greatly affected. It is also seen that there is no distinction between natural storm water courses and sewerage lines. It is common sight that these two flow together to debouch into the sea.

2.4 Ground Water Pollution:

The pollution may be defined as the deterioration in the chemical, physical and biological properties of water brought about mainly by human activities. Due to domestic and industrial activity and increased ground water withdrawals along the coast in VUA, there is deterioration in quality of water.

Urban Pollution

In order to know about urban domestic pollution, an attempt is made to analyse the data in urban residential zone in VMC and GM limits, barring thin coastal zone. A number of 171 samples fall in this urban zone. It indicates that in only 13% of samples, EC is within desirable limit and in 43% of samples only nitrate is within desirable limit.

In cities, raw sewage, contaminated water after bathing, kitchen wash, washings and solid waste discharged on land adversely affects the quality of ground water. The wastes are discharged on land without proper treatment. In Visakhapatnam City, the total water consumption for domestic purposes is to the tune of 135 MLD. The water after use is discharged in one form or other on land

without proper treatment. Added to this, the city has open drainage. The most wide spread means of sewage disposal is through a pipe connected to the street drain and in some cases it flows directly on open land. The waste water partly infiltrates into underground and joins ground water body. The sewerage is known to contain high ammonia and albuminoid. As such the potential indicator of domestic pollution is nitrate. Considering the pollution potential of nitrate, an attempt is made to study about nitrate distribution in urban area.

Ground water when not polluted contains less than 5 mg/1 of nitrates, but polluted waters contain large concentration of nitrogen. As per ISI standards, the desirable limit for drinking water is 45 mg/1, beyond this methanamoglobinemia takes place. The maximum permissible limit in the absence of alternate source is 100 mg/1.

The present study indicates that nitrate concentration in the ground water ranges from 0 to 556 mg/l, though the general range being 20 to 200. In all, 26% of wells have nitrate content more than 100 mg/1. 25% of wells have nitrate between 45 and 100 mg/1 and 49% of wells have recorded nitrate below 45 mg/1. The distribution of nitrate is shown in Fig.3. A perusal of figure reveals that, excess nitrate (>100 mg/1) occurs in Visakhapatnam and Gajuvaka urban areas covering an aerial extent of about 30 sq.km. The areas are Adarsha Nagar, parts of Sivajipalem, MVP Colony, Maddilapalem, Suryabagh, Dabagardens, Kotaveedhi, Chengalraopet, Gnanapuram, Marripalem, and Kancharapalem in VMC limits, old Gajuvaka, Gantyada, Tungalam and Vadlapudi in GM limits. Similarly in about 30 Sq.km nitrate is found to occur in more than desirable limit of 45 mg/l. It is also found to occur in excess concentrations in certain isolated localities. All the above areas are thickly populated and mostly located in low grounds, where the gradient is nearly flat. It is very common sight in the city that sewerage waste flows in open drains, which in many cases do not have even cement lining. About 35 million gallons of waste water is estimated to generate daily and 10 to 15% of water may go down and join ground water body. Therefore, the higher content of nitrate is attributed mostly to urban sewerage waste. The quantum of sewerage, gradient, duration of habitation and the density of population have significant effect on nitrate content in ground water. It could be seen that industrial effluents do not have effect on nitrate concentration in ground water.

Industrial Pollution

Due to industrial effluents released by Hindustan Zinc Ltd and Alum factory, the ground water in down stream areas of Mindi and Chukkavanipalem is highly polluted. In R.R. Venkatapuram village, the quality has deteriorated due to industrial effluents released by L.G.Polymers. Organic pollution is also observed in the immediate vicinity of this industry. In port based industrial zone and peripheral areas, the ground water is highly contaminated initially due to sea water and subsequently due to industrial effluents released by numerous industries located in marshy zone.

Sea Water Contamination

As a result of urbanisation, a large number of multi storied buildings have been constructed all along the coast in Visakhapatnam City. This has resulted in increase in ground water withdrawals and

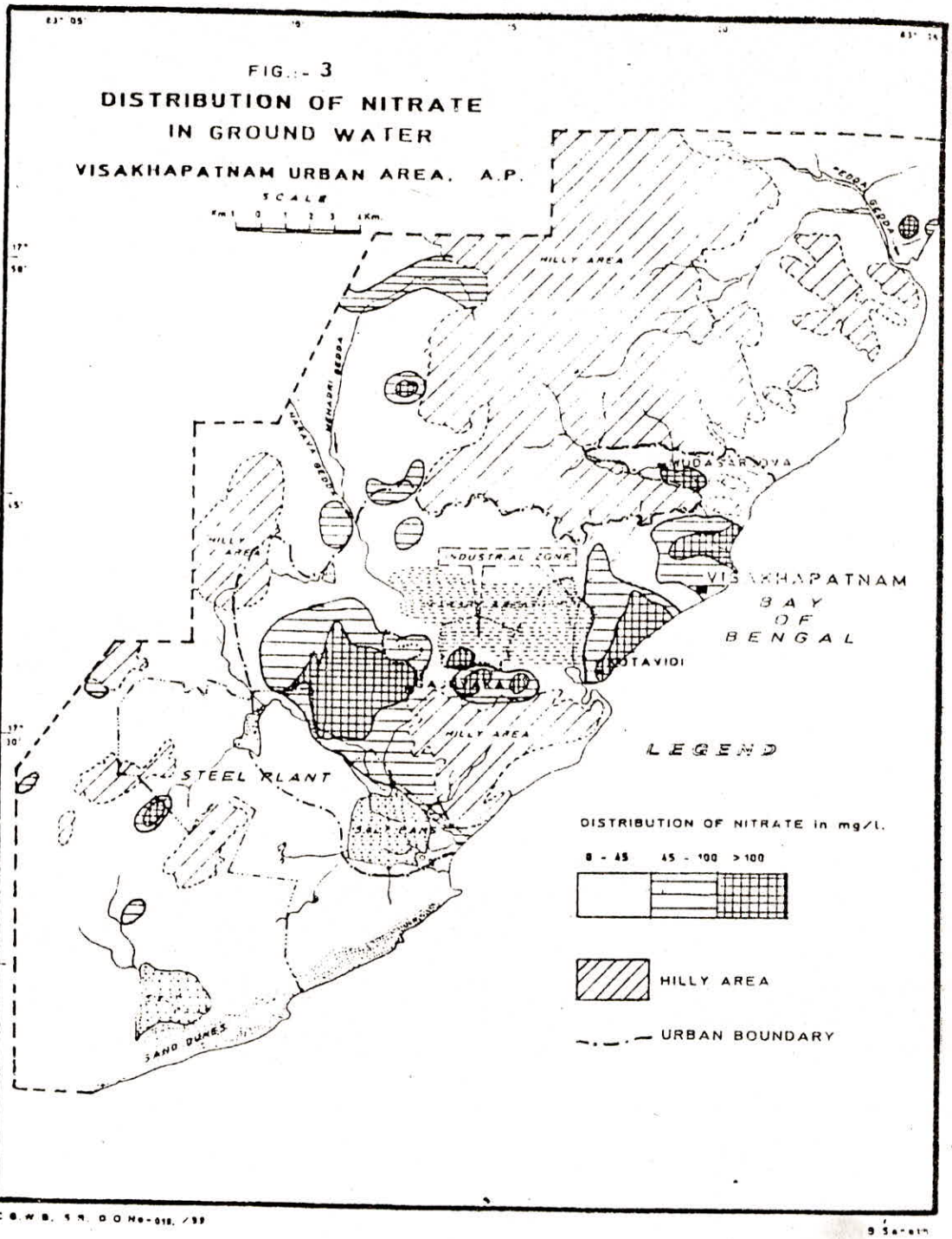


FIG. - 3
DISTRIBUTION OF NITRATE
IN GROUND WATER
VISAKHAPATNAM URBAN AREA, A.P.
SCALE
HILLY AREA
INDUSTRIAL ZONE
VISAKHAPATNAM
BAY
OF
BENGAL
STEEL PLANT
SAND DUNES
LEGEND
DISTRIBUTION OF NITRATE in mg/l.
0 - 45
45 - 100
> 100
HILLY AREA
URBAN BOUNDARY

consequent fall in water levels. If this trend is not arrested saline ingress may further intrude inland. Studies have indicated that seawater contamination is restricted to topographic lows along the coast especially between R. K. Beach and Harbour Channel. In other places, seawater contamination is observed locally.

3.0 CONCLUSIONS

Due to urbanization and industrialization in VUA, there has been rapid growth in population and consequent increase in water demands. With the surface water source unable to meet huge water demands, there is a lot of thrust on ground water resource. Due to urbanization processes, ground water recharge is highly affected. The increased industrialization and urbanization coupled with insufficient environmental protection measures have led to deterioration in ground water quality. The lack of sound sanitary management system, disposal of untreated industrial wastes and increased withdrawals of ground water along the coast are the main factors responsible for the quality deterioration in VUA.

4.0 SUGGESTIONS

1. Sewerage lines should be separated from natural storm water courses.
2. Comprehensive underground drainage has to be developed to safeguard ground water for further quality deterioration by sewerage.
3. Artificial recharge methods like rooftop harvesting structures, recharge pits in open lands, trenches in foot hills need to be taken up in a big way.
4. Strict measures should be implemented to ensure that industrial effluents are properly treated before being discharged on land.
5. Coastal fringe has to be protected from over pumping of ground water along the coast.

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REFERENCE

Hydrogeology and Ground Water Quality in Visakhapatnam Urban Area and Environs, Unpublished Report. CGWB (Feb 1999).