Groundwater Management in Bangalore – Impact of Municipal Waste Disposal Practices on Groundwater Quality – *M .A. Farooqi, Scientist, CGWB, Bangalore (Email: farooqima@gmail.com)*

Bangalore Metropolitan Region (BMR), spread over an area of 1279 km^2 is the fastest growing metropolis in Asia. It is estimated that almost 40 per cent of the population of Bangalore is dependent on groundwater. With groundwater contributing to domestic supplies to such an extent, the availability of this water not only in adequate quantity but also in desirable quality is a crucial factor in water management of the city. But in this urban environment pollution from anthropogenic sources is a serious threat to sustainability of groundwater.

Granites and gneisses constitute the major aquifer system in BMR. Groundwater occurs under phreatic condition in weathered rock; and under semi-confined condition in jointed and fractured granites and gneisses. Groundwater development in the area is mainly through bore wells. Due to over-exploitation, dug wells have become almost extinct. Long term water level trend shows a general fall except in the central parts which may be attributed to limited use of groundwater due to abundant piped water supplies, and leakage in water supply mains.

Although more than 5000 tonnes of Municipal Waste is generated every day in BMR, its management and disposal is not at all organised. Random dumping of garbage and wastes all around the metropolis is quite common, causing environmental pollution of land, water and air. Due to combined effect of large number and non-scientific nature of transit collection sites, partial collection, faulty transportation and delayed disposal of municipal wastes, groundwater in the study area is getting polluted. High nitrate content is the main cause of concern, ranging from nil to 554 mg/l. High levels of nitrates in groundwater above the safe levels (45 mg/l) when used in baby feed may cause methemoglobinemia, or blue baby syndrome.

Adopting an integrated approach in identifying the areal extent of pollution, and pollution vulnerable zones in the study area, GIS tool has been used. Drawing inspiration from DRASTIC a new model has been conceived with inputs in the form of different thematic layers to develop groundwater vulnerability map for the study area viz., Soils, Weathered Zone, First Fracture Depth, Fracture Density, Slope, Geomorphology, Land Use, Rainfall, Geology, Transmissivity, Drainage Density, Depth to Water and selected chemical quality parameters. Different thematic maps have been prepared in order to delineate the polluted zones, pollution vulnerability zones and pollutants. The types of maps included Soils, Weathered Zone, First Fracture Depth, Fracture Density, Slope, Geomorphology, Land Use, Rainfall, Geology, Transmissivity, Drainage Density, Depth to Water and selected chemical quality parameters viz., nitrate, chloride, potassium, sodium and hardness. Suitable weightages have been assigned in the order of merit considering the groundwater characteristics of the individual layer for integration by "Intersect method". The final resultant layer has been processed to get the total weights of all the polygons. The total weights obtained by integration had been regrouped to facilitate the classification of different zones by natural breaks method and polluted zones were grouped into five categories, namely *very low, low, moderate, high and very high*. Pollution under high to very high category is quite extensive and spread over the entire northern and eastern parts of the BMR. Western and South Western parts of the study area are relatively safe as they are found to fall under low and very low polluted categories in the map. Central part of the study area is also in low polluted category. Groundwater in remaining parts of the study area falls under moderate category. There is strong evidence of groundwater pollution from polluted surface water bodies. Further, Pollution Vulnerable Zones Map has been prepared using all the layers except Land use and Pollutant layers. A separate Pollutant Map using Nitrate, Potassium, Sodium, Chloride and Hardness has been used for validating the generated Pollution Vulnerable zones. It shows high to very-high pollution vulnerability category areas in eastern half of the BMR and Low vulnerability areas are predominant in western and southern parts of BMR. The central parts of the study area, though falling in high pollution vulnerability zone, shows low degree of pollution which is attributable to the seepage of large quantum of piped water (BWSSB), diluting the polluted groundwater and keeping nitrate concentration within safe limits. The plume direction matches with the flow directions of flow net map, giving additional validation to the derived maps. The land use map has been overlaid on the Pollution Vulnerable Zones as well as Pollutant Map. There exists a close proximity of anthropogenic activities with the vulnerable zones as well as pollutant zones generated. There is a close relationship of pollution in the high vulnerable zones and indicates a clear effect of urbanisation. At places, less vulnerable zones are also turned out to be high pollution zones and it may be attributed to the accumulation of waste generated at higher orders streams which are acting as big sewerage lines and, thereby, it validates the Pollution Vulnerable Zones Map. Correlation Matrix obtained for the weightages assigned to thematic layers on category basis shows high correlation between different weightages.. The GIS model developed to delineate Pollution Vulnerable Map of Hard rock terrain using ten thematic layers is named as VULPOL model.

Dilution method of de-nitrification has been attempted in the study area. The structures constructed to harness the groundwater and now used to recharge it artificially, have pumped enormous quantity of water into the aquifer system. A rise of more than 1.5 m water table has been observed as an impact of these structures. The chemical analysis carried out before and after construction of the structures has

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shown the decrease of nitrate content in the groundwater.

An Action Plan has been worked out for planners, managers and regulatory authorities to control the spread of pollution in the BMR. Water quality monitoring network should be strengthened and the data should be made available on the website. Important "factors" for water quality may be derived to opt for preventive measures. Recycling of sewage water should be encouraged which may be used for non-domestic purposes, and the slur can be used as manure. The land-fills and dumping sites should not be located in high vulnerability areas. In the name of developmental activity, no water bodies should be utilized. It is suggested to identify the small and tiny water bodies on 1:25,000 scale maps and these small and tiny water bodies should be utilized for artificial recharge to ground water system. The existing dry dug wells and bore wells may also be used for diluting the Nitrate pollution. Disused dug wells should not be used as dust bins which become sources of pollution. The sewage should be collected and treated properly before letting it into the drainage system, as it is going to pollute the less vulnerable areas to the maximum extent. Leakage through sewer pipes should be controlled effectively. The quality of well waters in use should be checked periodically for chemical as well as bacteriological parameters. Building byelaws should be suitably modified to include roof top rainwater harvesting in the house plan. This will reduce freshwater requirement, and decrease pollution of groundwater through additional recharge. Further, use of tertiary treated water for non-potable purposes should be made mandatory. Certain lakes should be utilized for rainwater harvesting and to recharge groundwater system only.

Preventing pollution in urban areas is also a public relations task and hence, there is need to educate people about proper waste disposal practices. Mass awareness programmes involving NGO groups and through print and electronic media will be very effective to get the message across.