International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 01, January-2018

EFFECT OF URBANIZATION ON GROUND WATER

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ABSTRACT: Water resources are under extreme pressure due to the burgeoning human population and rapid urbanization across the world. Urbanization in India is occurring at a rate faster than any other developing country. The planning commission of Govt of India estimates that 40% of country's population will be residing in urban area by 2030.In India, urban population grows more rapidly than rural population. Increase in the population during the last 50 yrs has led to rapid industrialization and high rate of urbanization which have created tremendous pressure on natural resources like land, air and water. Scientists estimate groundwater accounts for more than 95% of all fresh water available for use. Urbanization can decrease recharge opportunity decrease soil storage and cause low flows Ground water contamination occurs due to Improper dumping of contaminants in urban areas. Hence we need to preserve the quality and quantity of ground water to minimize the ill effects of polluted water.

KEYWORDS: Urbanization; Ground Water; Recharge; Population; Sources.

Introduction

High intensity of urbanization is observed in Indian cities in the last few decades due to the rapidly growing population and increasing economic activities. This phenomenon of rapid urbanization is causing unorganized and unplanned growth in most of the towns and cities. The ever-growing population and urbanization is leading to over-utilization of the resources, thus exerting pressure on the limited civic amenities, which are on the brink of collapse. One of the immediate fallout is the over-utilization of water resources near the cities and emerging urban centers. We are also facing constrains in choosing suitable geological sites which can provide necessary resources and favorable conditions. Urban expansion has increased the exploitation of natural resources and has changed land use/land cover patterns. The urban population of the world as a whole has been growing at the rate of about 3% per year, presumably faster than the existing world average population growth rate. India constitutes about 16% of the total of the world population, while as approximately 30% India's population lives in urban areas. The population has already crossed one billion mark and it is expected to rise further. This increase in population is leading to the haphazard growth and rapid expansion of the cites in India as more people are congregating in the urban areas and growing not only in number but also in area as well. The national Census of 2001 shows that with the current trend, at least 33% of the Indian population lives in urban centers, which was just 20% in 1981. The projected urban population of India by 2010 would 378 million against the rural population of 759 million and by 2025 urban population will be 605 million against 730 million of rural population while as by 2050 the urban population projected (971 million) is supposed to overtake the rural population (610 million).

Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a long term process.

The process of society's transformation from a predominantly rural to a predominantly urban population is known as urbanization. It includes two things-an increase in the number of people living in urban settlements, and an increase in the percentage of the population engaged in non-agricultural activities living in such places.

Impact of urbanization on groundwater

Urbanization likely to impact ground water quality and quantity leading to higher uncertainty and difficulties in management of pollution. Groundwater plays a fundamental but often unappreciated role in the economic and social wellbeing of urban areas. Although there are no comprehensive statistics on the proportion of urban water supply derived from groundwater, it has been estimated (Foster et al, 1998) that more than 1 billion urban dwellers in Asia and 150 million in Latin America probably depend directly on groundwater.

Urbanisation affects the quantity and quality of the underlying groundwater by (Foster et al, 1998):

- Radically changing patterns and rates of recharge
- Initiating new abstraction regimes
- Adversely affecting groundwater quality.

Recharge patterns can be affected by modifications to the natural sources and routes of infiltration by any change that makes the land surface more impermeable – the construction of roads, buildings and car parks, for example. Such areas, however, still have to be drained, and changes in natural drainage by canalisation of streams, construction of storm water drains and soakaways will collect the rainwater from these impermeable surfaces and produce locally-concentrated infiltration (Lerner, 2002; 2004). Further, the municipal water and wastewater services constructed beneath the ground may provide large volumes of additional infiltration from leaking water main and sewerage networks. As cities become larger, the water infrastructure may increasingly be dependent on surface water or groundwater brought in from outside the urban area itself. Other potential sources of additional urban recharge include on-site sanitation systems and the irrigation of amenity areas such as parks and sports grounds (Morris et al, 2003).

Urban processes and groundwater quality

The changing patterns and rates of recharge and abstraction can also have significant effects on groundwater quality. The net impact of the modified recharge on underlying groundwater quality is usually adverse; most of the sources of additional recharge are of poor quality (Table 1). Of these, unsewered sanitation is likely to be a particularly important source where septic tanks, soakaways, cesspits and pit latrines are used by dense urban populations living on shallow, vulnerable aquifers. This is confirmed by the results of published surveys of nitrate in groundwater in the briefing note on nitrate. Confirmation that the reported nitrate pollution originates from sanitation is provided by high observed incidence of microbial contamination in, for example, the urban areas of Merida, Mexico (Morris et al 2003) and peri-urban areas of Dakar, Senegal (Xu and Usher, 2006). Cross- contamination between unsewered and sewered sanitation and poorly maintained or illegally tapped into water distribution systems can also be expected.

Table 1. Impact on groundwater quality of sources of urban recharge (modified from Morris et al, 2003)

Recharge source	Importance	Water quality	Pollutants/Pollution indicators
Leaking water mains	Major	Excellent	Generally no obvious indicators
On site sanitation systems	Major	Poor	N, Cl, FC, DOC
On site disposal or leakage of industrial wastewater	Minor to major	Poor	HC, industrial chemicals, N, Cl, FC, DOC
Leaking sewers	Minor	Poor	N, B, Cl FC, SO4, industrial chemicals
Seepage from canals and rivers	Minor to major	Moderate-to-poor	N, Cl, FC, SO4, DOC, industrial chemicals
Amenity watering of parks, playing fields, private gardens	Minor to major	Good-to- moderate	No obvious indicators if from potable supplies, N, Cl, FC, DOC if with untreated or partially treated wastewater
B: boron, Cl: chloride, DOC: dissolved organic carbon, FC: faecal coliforms, HC: hydrocarbons, N: nitrogen compounds, SO4, sulphate			

As a result, the near-surface groundwater beneath many large towns and cities (Delhi, Lahore, Karachi) in developing countries is grossly polluted and can no longer be used for potable supply. This often drives both the municipal water supply operator and private users to look deeper for unpolluted groundwater. This can be at best a short-term solution, if the consequent deeper pumping induces the poorer quality groundwater to move downwards, eventually but inevitably compromising the quality of the deeper abstraction boreholes.

Investigating urban impact on groundwater

An assessment of the risk to groundwater from urban processes needs to take account of the interaction between the recharge and discharge pressures and the pollutant loading on the one hand, and the nature of the subsurface environment on the other (Schmoll et al, 2006). The potential for urbanisation processes to have an impact on the underlying groundwater is a function both of the aquifer's vulnerability to pollution and its susceptibility to the consequences of excessive abstraction. Hydrogeological environments are neither equally vulnerable to pollution (Morris et al, 2003) nor equally susceptible to the consequences of abstraction (Foster et al, 1998).

To investigate and understand the impacts of urban processes, it is essential to develop a conceptual model of the groundwater system (Schmoll et al, 2006). The conceptual model can then be refined as work progresses, and more knowledge of the ability of the subsurface to transmit or attenuate pollutants and of the scale and scope of the various urban processes is obtained. Guidance on assessing pollution risks is provided by Schmoll et al, (2006), including check-lists to help in data collection, and by Foster et al (1988; 2002). To estimate the potential urban pollution loading requires knowledge of population densities in the various types of central and suburban housing districts and of which of them are served by sewered and unsewered sanitation. Detailed guidance on assessing risk and estimating pollutant loading from unsewered sanitation is provided by ARGOSS (2001). Both planned and managed disposal of solid municipal waste in landfills and unplanned, informal disposal in brick pits, dry canals and river beds, in old wells and drains, into the street and onto disused land can contribute to the pollution load. Urban areas will almost certainly contain some industrial premises; guidance for assessing the risk is provided in the accompanying information sheet on industry. Vulnerability to pollution is a function of a) the ease with which water and pollutants can move to the underlying groundwater, and b) the attenuation capacity of the intervening material (Schmoll et al, 2006). The aquifer vulnerability concept is now well established, and methods have been developed for its assessment and mapping at various scales, including (Xu and Usher, 2006) for urban areas such as Abidjan and for peri-urban areas near Mombasa. It should be remembered, however, that many urban pollution sources such as sewers and storm drainage, solid waste disposal and fuel storage tanks are likely to discharge below the ground surface, bypassing any protective cover provided by the soil layer (Foster et al, 2002).

Overdraft and its consequences

Overdraft exists in many regions and has recently been described and labeled differently by several authors. Konikow and Kendy (2005) use the term groundwater depletion to describe extraction that causes persistent head declines in renewable aquifers or the mining of fossil aquifers. They add that groundwater depletion consists of a reduction of aquifer volume or a reduction in the usable volume of fresh groundwater within an aquifer. Overdraft is a form of "overexploitation"—a general expression referring to any groundwater development that engenders consequences that are negative or perceived as such, and is sometimes called "intensive groundwater development" to refer to the often beneficial economics of the early years of overdraft (Custodio 2002; Custodio and Llamas 2003). Correctly diagnosing an overdraft condition may not be straightforward since transient pumping effects may cause recharge and discharge of the aquifer to adjust over long periods (Theis 1940; Bredehoeft et al. 1982; Custodio 2002). Adverse effects of overdraft can include: uneconomic pumping conditions, water quality degradation through induced intrusion of saline or poor quality groundwater, flow reduction in streams, wetlands and springs, land subsidence, interference with pre-existing water uses and water rights and a gradual depletion of groundwater storage (Sophocleous 2003; Zekster et al. 2005). These problems in turn threaten the long-term sustainability of overlying economic activities and society. Land subsidence can increase flooding and drainage problems and disrupt infrastructure such as sewers and aqueducts. By lowering the potentiometric surface, overdraft may induce intrusion of lower quality waters (seawater, saline groundwater, contaminant plumes, or contaminants in the sediment or rock matrix) into aquifers, although these conditions also can occur in non-overdrafted aquifers. Consistent lowering of the water table can dry up wells, drain springs and wetlands and turn perennial streams into desert washes. In karstic aquifers, where flow occurs through fracture systems or in other aquifers with complex geology, lower groundwater levels may abruptly close hydrogeologic connections and cause drops in flows from springs or capacities of well systems. Any reduction of groundwater storage is detrimental if it threatens future water supplies, especially during drought. Pumping that permanently lowers water levels increases pumping costs for all pumpers for all future time. If these extra costs over time decrease economic productivity of a region, overdraft has a negative economic effect.

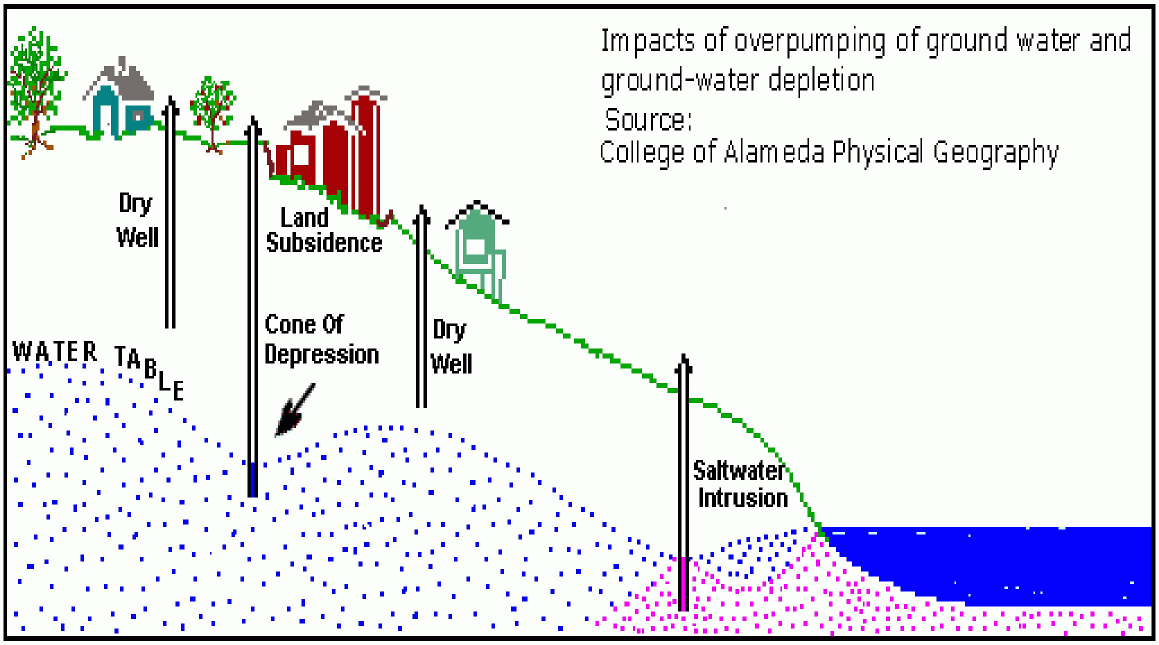

Fig.1:Impacts of overpumping of ground water and ground-water depletion

Pollution of Ground water

The sources of groundwater contamination are many and varied because, in addition to natural processes, practically every type of facility or structure installed by man and each and every human physical activity may eventually cause groundwater quality problems. The most common sources of groundwater contamination in urban areas are included below.

a) Domestic and municipal solid waste disposal
b) Disposal of domestic wastewater
c) Disposal of collected wastewater and effluents
d) Salvage and junk yards
e) Other urban sources

Conclusion

Urbanisation can lead to significant water quantity and quality impacts. The quantity impacts of urbanisation have been well documented in research literature due to it being the primary focus of research in the past. Research into quality impacts is relatively of more recent origin. The research outcomes are often conflicting, and consequently, it is difficult to discern cause-effect relationships for urban water quality impacts. The primary water pollutants identified in research literature include, litter, suspended solids, nutrients, heavy metals, hydrocarbons and organic carbon.However the quantitative assessment of these pollutants is subject to significant error and the mathematical formulation of the inherent processes has not been an easy task. This is a major failure in research studies. Consequently, attempts to correlate land use to pollutant loadings have been far from conclusive. Once again, even though qualitative relationships are generally evident, the derivation of statistically significant relationships has not been satisfactory. Therefore due to the quantitatively inconclusive nature of research outcomes, the management of water quality impacts in urban areas has proven to be an extremely challenging task.

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