Groundwater Governance in Kavaratty Island of Lakshadweep, India

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Abstract: Kavaratty is a small tropical island of Lakshadweep archipelago in the Arabian Sea with an area of about 3.63 sq.km and supports a groundwater dependent ecosystem. Even though the island receives an annual rainfall of about 1600 mm, freshwater scarcity is felt in parts of the island due to various factors such as low elevation of ground and low aspect ratio. High density of population, high density of deep rooted vegetation, shallow groundwater condition, improper sewage disposal and increase in groundwater draft impart stress on the freshwater resources in this island in terms of quantity and quality. It has got about 130 wells per 1000 persons. The estimated groundwater recharge and groundwater draft are 1.85 MCM and 1.1 MCM respectively and the spatial and temporal variations in water quality are very high. The shallow fresh water, which floats over the seawater in the form of lens, is very much susceptible to pollution and cleansing of aquifers is a difficult task as the lateral movement of ground water is restricted. High concentration of nitrate (NO_3 > 50 mg/l) is observed in many wells and ponds indicating sewage pollution. The strategies on groundwater management for its sustainable development and protection from quality impairment are discussed in the paper. It is essential to maintain a pure drinking water supply scheme differentiated from other domestic supplies. Rooftop rainwater harvesting is being successfully practiced in many of the houses and in government quarters in the island with individual beneficiary maintaining the system and thereby ensuring essential supply of fresh drinking water throughout the year.

Fixing a price for pumping ground water can deter the misuse of such a drinking water system for other domestic uses. Proper management strategy for the island is dealt with in the paper. It involves an integration of deterrents and promotional options for regulation of groundwater draft, maintenance of proper sanitation facilities, and rainwater harvesting systems. This will help to improve the water quality as well as reduce stress on the freshwater lens. The groundwater governance of this kind visualizes the overall physical and aesthetic improvement in the life of the island without affecting the ecosystem.

INTRODUCTION

Kavaratty is one of the 10 inhabited coral islands of Lakshadweep archipelago with a population of 10113 (2001 census). It lies between north latitudes 10°31′ and 10°35′ and east longitudes 72°36′ and 72°39′ and is conspicuous by its bottle guard shape. It is situated in the eastern margin of the coral reef with lagoon in the west and having ground elevation ranging from less than a metre to about 6 m above mean sea level. The narrowest part of the island towards southwest is known as chicken neck. The thin lens of shallow freshwater floating over the saline aquifer system is renewable but limited in quantity and is variable both in space and time. As the island is devoid of natural drainage system groundwater dependent ecosystem has been developed here. Coconut is the major crop of the island and there are about 86,000 trees with a density of about 240 trees/hectare. Irrigation practices are limited to wetting of vegetable crops raised by agricultural department and fodder cultivation by animal husbandry department. Domestic requirements and evapo-transpiration are the major components of groundwater consumption and human activities are the cause of groundwater pollution in the island. Hence, water governance in this island aims at providing sufficient quantities of water of acceptable quality by sustainable development of the groundwater resources, its protection from quality impairment and distribution under economic and ecological efficiency.

GROUNDWATER CONDITIONS

Freshwater recharge in the highly porous coral sands is hydraulically connected to surrounding sea and the saline aquifer beneath it. It is under phreatic condition and is being affected by tidal fluctuations in the sea. The water levels monitored from 23 key wells and electrical conductivity (EC) measured from 32 wells, which are spatially distributed, has been analysed for seasonal and diurnal changes. The depth to water ranges from 0.6 m to 4.15 m below ground level (bgl) and the depth of wells ranges from 1.6 to 4.6 mbgl.The hydrogeology of the island depicts the influence of shape of island on freshwater lens formation (Fig. 1). The tidal influence on the water level is dominant and the seasonal changes do not reflect the quantitative changes in the groundwater resource. However, the effect of tides on the water quality are very marginal and the seasonal variation in quality are very high (Fig. 2). The amplitude of seasonal quality variation measured as EC in the northern half of the island is low due to comparatively thick freshwater lens. The quality variation observed during summer is about 20% only. The southern part of the island is highly sensitive for groundwater draft as well as recharge and a delay in monsoon or reduction in rainfall results in drastic deterioration in quality.

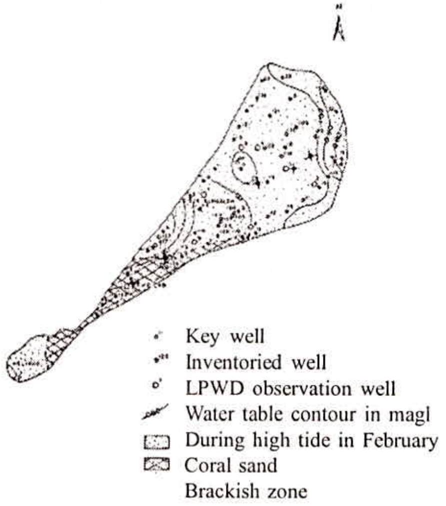

Fig. 1. Hydrogeology of the island.

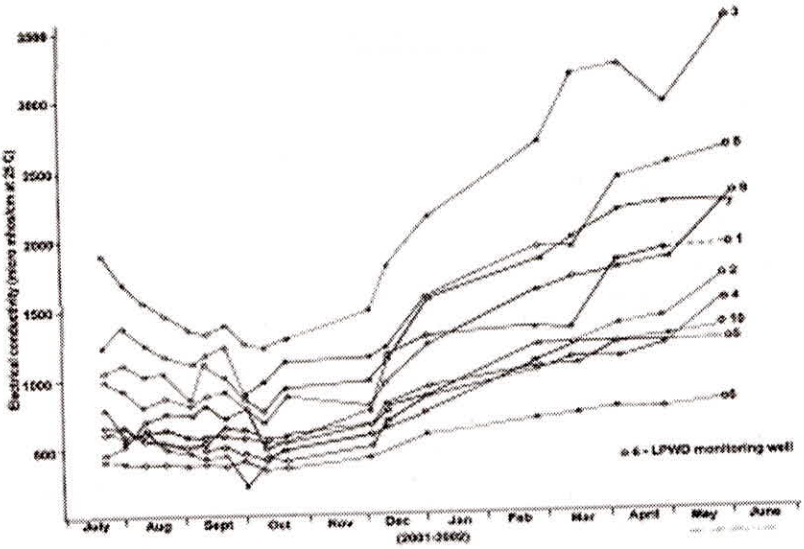

Fig. 2. Seasonal fluctuation in water level.

The groundwater is extensively developed by dug wells as can be seen from the number of groundwater abstraction structures in the island (Table 1). People use ponds and tanks for bathing and washing purposes, which minimizes the ground water draft for domestic use. Modern living has given rise to increased extraction of groundwater through pumping wells.

Table 1. Groundwater abstraction structures in the island

No. of dug wells	Well density/ sq. km.	Well density/ 1000 persons	No. of ponds	No. of filter points
1307	360	130	148	217

Rainfall is the only source for groundwater recharge in the island. The effective recharge to the groundwater body takes place during June to September when Potential Evapo-transpiration (PET) is less than the rainfall. Recharge to ground water was estimated based on daily water budgeting. It was established based on daily water budgeting carried out for 13 years that there is a very good correlation between water surplus and annual rainfall. The mean value of annual water surplus was considered for estimation of average recharge. The average annual recharge computed is 1.85 MCM. In the draft side groundwater draft for domestic as well that of deep-rooted vegetations were accounted for. The total annual draft worked out is 1.10 MCM leaving a balance of 0.75 MCM.

Water Supply

Ground water is mainly used for domestic purpose. Almost all the houses have their own dug wells and water is lifted manually. In some of the houses two dug wells are available, one non-energized (hand drawn) well, exclusively to meet the drinking water needs, while the second about 5-10 m away from the other, is energized to meet all other domestic needs. Generally deterioration in water quality is observed in pumping wells. The water requirement for domestic purpose at the rate of 40 litres per head is about 3.5 lakh litres a day. Three water supply schemes are operating in the island, one based on desalination process by electro dialysis which uses seawater as its source and the other one based on reverse osmosis (RO) process which uses ground water in the southern part of the island as the source. The third desalination plant functioning since May 2005 is based on "Low Temperature Thermal Desalination" technology and has a production capacity of about 100,000 litre/day. Rooftop rainwater harvesting is being successfully practiced in many of the houses and in government quarters in the island with individual beneficiary maintaining the system and thereby ensuring essential supply of fresh drinking water throughout the year. Rainwater is having electrical conductivity less than 200 micro mhos/cm and is the best quality drinking water source in the island.

GROUNDWATER GOVERNANCE

The sustainable development of freshwater resources and its management can be ensured through effective water governance by island authorities. To protect the fragile hydrodynamic equilibrium between the fresh water lens and seawater it is necessary to regulate the groundwater draft in the island. Regulation of groundwater draft, conservation of water resources, roof water harvesting, protection from pollution, optimization of natural flora, and pricing of water are the important components of groundwater management in the island. This will ensure the optimum development of the freshwater lens so as to avoid deterioration of water quality by mixing of seawater. Conservation of fresh water through rainwater harvesting and desalination of brackish water can be adopted to meet future enhanced requirements as well as to reduce stress over the freshwater lens.

Regulation of Draft

As the groundwater draft is mainly for domestic purpose any kind of restriction on draft will have social consequences. Hence, socially viable regulation has to be introduced to restrict pumping of wells, which cause quality deterioration. The adverse effects of pumping can be minimised if the pumped wells are shallow, spatially distributed and pumped at low rates. Wherever the freshwater lens is very thin, infiltration galleries are obviously preferable to wells (Barker, 1984). As the thickness of freshwater lens in the northern part of the island is maximum (Fig. 1), small capacity (0.5 HP) pumps can be allowed for lifting water from those wells having EC less than 2000 throughout the year. In areas south of dak bungalow, use of pumps for water lifting should be banned, as the freshwater lens is comparatively thin.

Skimming wells are ideal for those parts of the island where the thickness of the lens is less. Skimming wells are constructed with vertical or inclined shaft with a sealed bottom connected to several small diameter perforated pipes placed at the bottom of trenches filled with gravel. The pipes lay just below the mean water table such that they follow the lens thickness contour. For better efficiency the galleries are to be oriented parallel to longer axis of the island (Petersen, 1984). The depth of the well should be less than 1/3 of the depth to the interface for homogenous isotropic aquifer (Chandler and Mc Whorter, 1975).

Water Conservation

The traditional water conservation practices in the mainland have little application in this Island. Lack of drainage system and highly permeable coral sands demands specific groundwater conservation methods. Rainfall is the only source of recharge and the highly permeable coral sands allow the entire rainfall to reach the freshwater lens and get adjusted by way of diffusion leaving no scope for surface run off. The ponds and tanks in the islands minimise the use of fresh water by collective use of it for washing and bathing purposes by clusters of families. The use of such tanks is to be encouraged and are to be maintained clean by regular maintenance. These ponds and tanks are water conservation structures and cannot be considered as effective recharge structures as the lateral movement of these mostly polluted pond waters are seldom noticed.

Roof Water Harvesting

Even though nearly 80% of the rainfall gets recharged into ground water, major part of it is lost due to evapotranspiration and mixing in the zone of transition. Roof water harvesting for domestic use provides a safe alternative to meet the drinking water needs. Hence roof water is to be made mandatory for all buildings, both in private sector and government sector, in the island. It is estimated that each islander can get a minimum of 10 litres of drinking water per day throughout the year from his own rooftop.

Protection from Pollution

The freshwater lens is dynamic with an active vertical component and a restricted lateral component. Because of this situation the lateral movement of pollutants reaching the freshwater lens is very low. This is evident from the coloured polluted water restricted around the bathing ponds in the island. A similar situation exists at point pollution locations especially of oil spills around the generator stations where diesel is the source for power generation. There is no natural way out for the contaminants once they enter the system, as the lateral flow is restricted. Utmost precaution is to be taken in the handling of diesel not to spill it on the ground. Proper sanitation with a centralized sewage processing will help maintaining the quality standards for the fresh water in the island.

Optimisation of Natural Flora

Protection of natural flora in these islands is to be viewed as a part of water management. The existence of fresh water in the island is indebted to the flora, which protects the island from erosion and destruction of coral sands. At the same time the coconut plantation by virtue of its deep penetration of the roots withdraw a large quantity of fresh water from the groundwater lens. Hence it is essential to have the optimum spacing between the coconut trees, which will ensure maximum yield without wasting the precious ground water. In these islands the density of coconut trees are 150-230% higher than the recommended one thereby causing additional stress on the groundwater regime. The efforts of the administration earlier for thinning out of the coconut plantation by way of paying incentives for selective felling of the trees had a negative impact as it prompted some of the islanders to plant more seedlings so that in four years it will be a tree for which incentive could be claimed for felling. Here the lack of public awareness was the cause of failure of a noble venture. Mass awareness schemes should be taken up in a large scale to educate the masses on the groundwater scenario and need for its conservation thereby ensuring the people's participation in the protection and conservation of fresh groundwater available in the island.

Pricing of Water

Pricing of water can be considered as a deterrent in the misuse of drinking water as well as polluting of ground water. The fresh water produced through desalination is costly. Desalination by Low

Temperature Thermal Desalination (LTTD) technology is economical than thermal digestion and Reverse Osmosis plants. The cost of production of fresh water from LTTD plant in the island is worked out by National Institute of Ocean Technology, Chennai as 39.80 paise per litre, which after government subsidies and grants will be 15.72 paise per litre. If power is made available at a concession rate of Rs. 3 per kWh the cost of water can be reduced to 9.12 paise. The drinking water should be supplied at this cost and it should be totally waved for all houses having rainwater harvesting structures subjected to a maximum of 40 litres/day/head. This kind of pricing will deter the misuse of fresh water generated as well as reduce pollution of fresh groundwater resources and its over-exploitation. The money spent by government on health and hygiene of the people of the island will be drastically reduced by maintaining the pure domestic water supply.

CONCLUSION

The freshwater sources of the island can sustain the development by adopting the above water governance and management practices. The higher demands in future beyond the sustainable limits of freshwater resources in these islands can be managed through desalination of brackish water sources, for which proper pricing policy, taxing the high end users, to cover the cost of desalination will be a viable option. Mass awareness schemes should be taken up in a large scale to educate the masses on the groundwater scenario and need for its conservation thereby ensuring the people's participation in the protection and conservation of fresh groundwater available in the island.

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