Groundwater Management during disasters in India

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Abstract

The disasters events that occurred in the last three decades in India have also affected the water resources of the respective areas in various ways, some times in a deteriorating way, initiating response from the stake holders of the area. So far, the action of these stake holders in general, have been, playing the role of a responder to the disaster. The learning from these experience can be utilized for coping with such future events. The Groundwater plays a vital role to restore water supply in an area affected by disaster, especially during the recovery and rehabilitation period. The scientific knowledge of occurrence and movement of this precious, invisible resource through various hydrogeological surveys, exploration and monitoring will help to protect and utilize this resource at the time of disaster. Further, in the changing scenario with paradigm shift in disaster management policy towards disaster preparedness from that of responsive role, the experience gained, knowledge, expertise and data base available, can help to achieve the reduction of the impact of the disaster by protecting the available fresh water sources and restoring the potable water supply with minimal loss of time. The experience of impact of disaster on groundwater regime and its management are discussed in this paper.

Key words : Groundwater, ground water management, disaster and groundwater

Introduction

The disaster events which occurred in the last two to three decades in the country, like the Severe drought of 1987, affecting several parts of the country, Super Cyclone of Odisha of 1999, the Bhuj earthquake, Gujarat of January, 2001 and the Tsunami of 26th December, 2004, which hit the coastal areas of southern India, remind us of the disaster it created and its impact on water resources. This also showed us, how these disasters have ruined the life of millions, as preparedness to face such events were not in place. Such events may recur as seen else where in the world like the recent cyclone of Myamnar (May, 2008), the earthquake of China (May, 2008) and the very recent earthquake followed by tsunami of Japan (March, 2011). The various

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Governmental agencies can prepare a management plan to act in such events to restore the normalcy to these areas as early as possible, using the scientific knowledge and expertise we have gathered over the years about the natural resources. The constitution of National Disaster Management Authority, State Disaster Management Authority and the District Disaster Management Authority after the enactment of Disaster Management Act 2005 are examples of some of the steps initiated by the Government in this direction.

World wide figure shows that floods represented 50% of the disasters between 1990-2001 and drought 11% and Asia faced 35% of all water related national disasters during the same period (UNESCO, 2006). In terms of life too, drought claimed the greatest number of victims during the same period, world wide.

Need for drinking water

When everything is shattered, the human and cattle population of the disaster affected areas, will require first and primarily, the potable water to drink for survival apart from food, fodder, clothing etc. The experience in the above mentioned disaster events of our country has also shown that the primary effort of different agencies were to restore water supply for drinking, though on emergency basis packaged drinking water is distributed. If the area is naturally endowed with fresh groundwater, it will be justifiable and economical to develop/redevelop groundwater, as it is available at the place of requirement.

National Disasters – Indian Experience

Super Cyclone of Coastal Odisha

The Super cyclone that hit the coastal Odisha, in the eastern part of India, in October, 1999, created unprecedented havoc for the human life, cattle and property. 9893 people died and life came to a stand still for several days (Gupta, M.C et al, 2001). It took several months to limp back to normalcy. During the super cyclone of October 1999, well hydrographs (Figure 1) showed sudden rise only to decline of the normal level within a short period. Except in the fringe areas of the coast where the dug wells were contaminated by seawater flooding, there was hardly any effect of cyclone on the tube wells and ground water regime (Das et al., 2005). The contaminated wells were also developed for several days to pump out the saline water accumulated in the well to try to improve the quality groundwater.

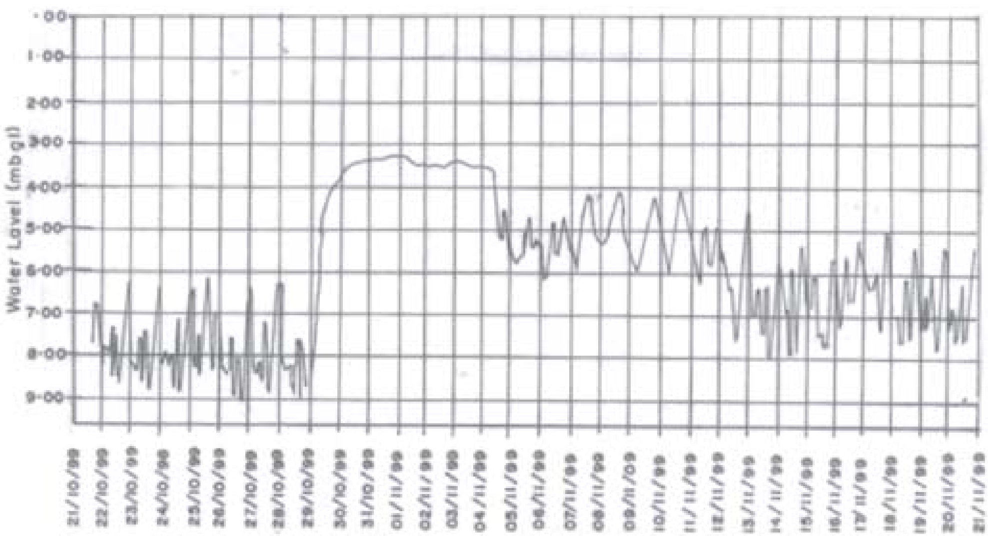

Figure 1: Hydrograph of network stations at Bhubaneshwar showing abrupt rise in water level which indicates effect of cyclone of 29th Oct 2009

This experience has shown that for drinking water supply during such events, it is important to identify the areas which are likely to be submerged by sea water flooding and also the time period for which it will remain submerged, so that alternative water supply can accordingly be planned. To overcome the effects of flood, mapping of vulnerable areas which may include, identification of aquifers which have substantial resources and that are not likely to be affected by floods have to be carried out to face such events in a planned way. Thus the experience during the Super cyclone of Odisha could establish a fact that the ground water remains a sustainable resource even in periods of cyclones.

Frequent droughts

Over all, considering deficiency in rainfall, India's two third of the arable area is at one time or other susceptible to drought (Subbiah, 1993). A study which analysed the rainfall data of the country from 1875 to 1998, for 124 years noted that there were three occasions i.e. during 1877, 1899 and 1918 when percentage of the country affected by moderate and severe drought was more than 60 percent, which indicated the severity of the situation. During the period from 1871 to 2009, India experienced 27 major droughts. According to the Emergency Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED) report, droughts affected nearly

1,061 million people and killed nearly 4.25 million people in India during 1900-2007. Droughts are very common in some parts of our country. The governmental agencies have even demarcated some areas as drought prone from the experience of recurrence of such droughts. These include parts of Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Tamil Nadu, Bihar, Jharkhand, Uttar Pradesh, West Bengal, Odisha, Haryana and Jammu & Kashmir. Droughts are responsible for degradation and desertification of nearly a third of the world's arable land (UNESCO, 2006). The drought of 1987 was one such event which affected several parts of our country. Low rainfall adversely affected the ground water recharge. The effects of rainfall scarcity on ground water regime were systematically studied in the drought year of 1987 in selected observation wells of Odisha. The study generally showed a nominal decline of ground water level to the tune of 0-2 m in the coastal areas except in Baleswar district where the steep decline in water level of the order of 2-4 m was due to accentuated withdrawal of ground water during the drought period. The piezometric levels of aquifers deeper than 100 m had been less affected than the upper groups of aquifers. This may be due to excessive withdrawal of ground water during the drought period through shallow tube wells (Das, 2005).

This experience has also shown that the deeper aquifers identified can be utilized even during drought situation as they are less affected as seen in the discussion above. In Rajasthan identification of deep (100 to 500 m deep) aquifers like Lathi Sandstone with an aerial extent of 3,270 Sq km has proved useful during drought. The management solution of drought is usually preventive, as well as mitigating the drought. The long term preventive methods include integrated use of surface and ground water, water conservation (through contour bunding, gabbion structures, gully plugs etc), artificial recharge of ground water (through percolation ponds, check dams, rain water harvesting using roof top, paved areas etc.) and induced recharge.

Bhuj Earthquake

Drastic changes in the groundwater level were observed during several earthquakes. The extent of the change (fluctuation) of groundwater level depends on the earthquake's magnitude, distance from the epicentre and earthquake source mechanism. The earthquake of 26th January, 2001, destroyed the entire city of Bhuj (in the state of Gujarat, Western part of India) and 800 villages around, disrupting the entire water supply system. The digital water level recorders showed fall and rise in water level during and afer the earthquake. There was no significant change in the quality of water drawn from dug wells and tube wells located in different formations (Chadha et al., 2006).

Remote sensing data aided by detailed geophysical survey was carried out to identify drilling sites as an immediate step after this earthquake on war footing. To restore water supply nine deep drilling units were engaged to drill tubewells were mainly confined to Bhuj Cretaceous sandstone. About 55 tube wells were drilled in the depth range of 70 to 156 m to utilise 45 of them. The total water supply of 20,000 cubic metre could be restored initially and then slowly other tube wells were also rehabilitated and water supply restored (Chadha, et al., 2006).

Tsunami

Tsunami is a wave of high energy, which is generated by an earthquake or landslide in the sea. An earthquake of 9.3 magnitude on the Richter scale struck the active subduction corridor along the eastern margin of the Indian lithosphere off the coast of Sumatra in Indonesia. The waves reached Andaman and coasts of Tamil Nadu and Andhra Pradesh. These sea waves on reaching shallow water were transformed into forceful tidal waves of great heights (10-30 m) creating vast damages. Unlike Super cyclone of Odisha, the sea water intrusion due to tsunami adversely affected the groundwater, in terms of quality and quantity. The water level declined by 0.5 to 5.5 m after the Tsunami. The Tsunami waves also resulted in the intrusion of saline water up to 2 km inland at some places. It damaged several hand pumps that were being used as drinking water source in rural areas. Pumping was continued for several days in dug wells to pump out the brackish water which entered these dugwells due to tsunami. The groundwater that remained unaffected was utilized for drinking water needs, immediately. And further new tube wells were drilled to meet the water requirements in other areas especially in Andamans (Keshari, et al., 2006). How ever this event also showed that there should be management plan in place to face such situation.

Groundwater resource, monitoring and database

Groundwater resources comprises of two parts namely dynamic, in the zone of water table fluctuation and static resources, below this zone, which usually remains perennially saturated. As per the India's National Water Policy, 2002, the dynamic groundwater resource is essentially the exploitable quantity of groundwater, which is recharged annually, and is also termed as replenishable groundwater resource. The annual replenishable groundwater resource of the country is estimated to be 433 billion cubic metres (bcm) and the net groundwater availability is 399 bcm after allocating 34 bcm for natural discharges during non-monsoon season. The annual groundwater draft for the year 2004 was 231 bcm, out of which 213 bcm is utilised for irrigation and 18 bcm is used for domestic and industrial purposes (Chattejee, 2009).

Hydrogeological approach in disaster areas will vary depending upon the aquifers, its disposition and geomorphological conditions for example, the area affected by earthquake will have different impact from the one affected by tsunami in the coastal areas. The shallow aquifers in large alluvial river basins can be substituted by deeper confined aquifers of the underlying geological strata. Development of static ground water resource is one of the solution when the dynamic resource is contaminated or quality deteriorated due to the disaster. This will be more appropriate in case of drought in the arid regions also.

The hydrogeological survey of the entire country has already been carried out by different agencies and some areas were even covered for detailed survey. The groundwater levels of the shallow and deeper aquifers are being monitored by the national (Central Ground Water Board, Ministry of Water Resources) as well as State level agencies dealing with groundwater since 1969. Quality of groundwater is also monitored generally once a year by these agencies. Groundwater renewability in general is considered in terms of recharge, discharge and renewable time. However, during disaster situation where human lives are at stake and drinking water supply has to be restored, the groundwater from deeper aquifer or even non-renewable entrapped fossil water bodies can be utilized if they provide adequate yields. This cannot, however, substitute for regular water supply.

Thus, the available hydrogeological knowledge can be utilized for proposing suitable alternative to reliable groundwater resource in case of such natural disasters, using the experience gained from these disasters. This will form some measures for the exploitation of groundwater when the country is facing such situation in the future. Renewable supplies of groundwater tend to be more reliable than surface water supplies and groundwater storage affords the possibilities of enhancing the quantity and often the quality of available supplies. Groundwater and groundwater formations are especially valuable in time of intensifying scarcity. Groundwater will become increasingly important as a buffering resource in the time of drought and as a resource that can be managed more intensively to enhance water availability and quality in the time of chronic and acute scarcity (Henry, 2011).

A conceptual groundwater model can also be developed for various basins/sub-basins initially, with the available data base and the confidence level of this model can be enhanced when it is updated by more data which is made available and when it is tested by the events. Mathematical model is the model which is used to simulate the field situation by means of governing equations thought to represent the physical processes that take place. In case of ground water simulation studies the mathematical model simulates ground water flow indirectly by means of governing equations to represent the physical processes that occur in the system, together with equations that describe heads or flows along the boundaries of the area for which the model has been developed (Anderson et al., 1992). Generally deeper aquifer is used in case of drought as discussed above and in such cases the data of deeper aquifers are not generally available like phreatic aquifer in space to have good control, for the development of model. This can often be a complicated task to achieve. However the process has to be initiated and then the required data can be acquired in due course of time to have more confidence over the model. This can be a tool for good planning and management of water resources in case of disasters.

Conclusion

The review of the major disaster events in the recent past clearly shows that groundwater resources are affected in a varying intensity. In most of the disasters discussed, the impact on groundwater was not severe. The normal or alternative water supply also could be restored in a nominal period, except when new wells were to be drilled like in the case of earthquake affected areas of Bhuj and tsunami affected areas of southern part of India and Andaman. However, keeping in view the recent experience of Japan in March, 2011 earthquake and tsunami it is suggested that there is a need for the development of data base and assessment of the vulnerability of the disaster prone areas of the country from multi-hazard point of view including groundwater to protect the groundwater resources as well to plan for the utilization of this precious resource in the event of any disaster. Using the knowledge, experience and the data available on quantity and quality of the groundwater occurrence and its movement, necessary steps shall be taken in this direction to protect, conserve and utilize this resource at the time of need.

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