Daily News epaper

Management of groundwater for the sustainable development of water supply in Sri Lanka.

Groundwater forms the invisible part and plays a key role in the hydrologic cycle. Although Groundwater is invisible, its impact is visible everywhere. As climate change gets worse, the need for groundwater will become more and more critical. Groundwater may be out of sight, but it must not be out of mind.

The hydrologic cycle is a sequence of water transformations that occur in the circulation from the atmosphere onto the surface and into the subsurface regions of the earth as groundwater and then return to the surface and the atmosphere once again.

The physical and chemical environmentsof groundwater are completely different from the surface water environment.

Groundwater stores within the porous subsurface formation, known as 'aquifers', and moves through it from areas of recharge to discharge areas at a very slow rate. Sometimes, more than a hundred years is required to reach the discharging area from the initial recharging area.

Naturally, the groundwater level of the aquifer fluctuates with its recharging conditions.A decrease in groundwater level indicatesa decreasa in recharge and vice versa. In addition, groundwater quality also changes with the varyingrecharging conditions of the aquifer.

The drastic changes in the groundwater level induced due to climatic change or excessive pumping of groundwater could impact the environment in zone of influence and also the water quality. The schematic diagram of a pumping well and groundwater level behavior is given in figure (1).

Therefore, two scenarios are to be considered in general in formulating groundwater pumping particularly for irrigation purposes, water supply schemes, industries, dewatering purposes, etc.

Scenarios 1: Do not charge the regional groundwater flow direction.

Scenarios 2: Do not give a large impact on the groundwater level of the area.

Both above scenarios indicate that groundwater pumping should be implemented with minimum impacts on the existing environment.

Development of groundwater in Sri Lanka.

The extraction of groundwater for water supply schemes(WSS) that provide pipe-borne water to consumers in Sri Lanka has been started since 1970.

At present, more than 4000 rural and semi-urban WSS are using groundwater sources such as springs, dug wells, well with laterals, shallow and deep tube wells. These intakes are constructed on different aquifer systems and also in different climatic zones of the country. Some groundwater intakes are used only during dry periods while others are in operation throughout the year. The daily groundwater extraction of 90% of these existing WSS varies between 40 and 500 m3.

Hydrogeology and aquifers of the country.

About 90% of the country is underlain by the hard rock where the aquifers are not highly productive due to the low porosity.The rest of the area, mainly the north and northwestern parts are composed of limestone with higher productive aquifer formations due to relatively higher porosity.

Six (06) main aquifer types have been identified and demarcated in the country (Panabokke and Perera, 2005) (figure2)based on the studies carried out over the last 25 years mostly by the Water Resources Board (WRB) and the National Water supply and Drainage Board (NWSDB). Each of these aquifers has distinctive characteristics, specific issues, and needs. Therefore, each aquifer will require its specific management strategy and actions for the development and sustainable management.

The main aquifer types of Sri Lanka are; (i) shallow karstic aquifer, (ii) deep confined aquifer, (iii) coastal aquifer, (iv) alluvial aquifer, (v) shallow regolith aquifer of hard rock and fractured hard rock aquifer, and (vi) lateritic aquifer. The deep confined aquifers and most fractured hard rock aquifers are naturally protected against pollution. The impact of anthropological activities is

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frequently observed in the shallow regolith aquifers, coastal sandy aquifers,and shallow karstic aquifers in Jaffna(Panabokke and Perera, 2005).

Issues of the groundwater-based pumping water supply schemes.

The presence of a higher concentration of iron, manganese, hardness, fluoride, alkalinity, salinity (sometimes due to saltwater intrusions), etc. in groundwater causes quality parameters to exceed the SLS 614:2013 requirements. These parameters often create water quality issues that are different from water supply scheme to scheme. In some cases, enrichment of water quality parameters is limited only to the dry period.In addition, most of the WSS are facing issues such as deterioration of water quality and reduction of the pumping capacity, several years after commissioning.

The reduction of pumping capacity is a common issue in most groundwater intakes due to the depletion of the groundwater table. Some intakes show a continuous reduction of pumping capacity while others show only seasonal reductions. The pumping capacity reductions of intakescan be attributed todecrease in the groundwater flow to the intakes as a result of well and aquifer problems. The occurrence of aquifer problems is mainly due to climatic consequences and man-made issues. The well problems are due to increased well losses in well structures (well screen and fractures) and operational issues. The specific capacity (pumping rate/ drawdown) is the common measure of well performance andcontinuous reduction of specific capacity will lead to the reduce useful life span of the well. The average lifetime of most of the groundwater intakes inthe country is about 10-15 years which is very short compared to that of the developed countries which isabout 40 years

The processes involved in water quality deterioration and reduction of specific capacity are complex though they are directly related to natural processes, man-made activities, and limited understanding of hydrogeology and groundwater pumping process. Identification of the potential issues, assessment, and mitigation istimely and necessary to be addressed urgently.

Influencing factors for sustainable groundwater extraction.

At the initial stage of the well construction, an assessment of optimum yield for the groundwater sources of WSS was carried out as per the agreed pumping test procedure with due consideration for the hydrogeological, general climatic, and land use conditions. The optimum yield is affected with time both due to natural and manmade factors. They are changes in the hydrogeological environment in the vicinity and the recharge zone, climatic condition, construction weaknesses, and operational inefficiencies.

The prediction and identification of the above issues are complex and sometimes it is a multitude of all the above factors. However, the presence of observation boreholes close to the intake in the same or with a similar hydrogeological unit is useful to monitor and predict the anticipated quantity and quality issues.The variation in the pumping capacity of groundwater intake due to climate, construction issues, operational matters, and manmade issues are described in the sections below

Annual rainfall variation and its effect on groundwater extraction

Generally, there are three stages (1st stage, 2nd stage, and 3rd stage) of groundwater environments commonly identified in many groundwater intakes concerning the variation of the annual climatic cycle (Dillon,P.2009). The time taken for reaching the particular stages of each intake is different and entirely depends on recharging conditions.

1stStage: When pumping wells are commissioned, natural replenishment from the annual climatic cycle is helpful to recover the storage loss and aquifer drainage loss. Any significant impact from other groundwater users in the area, recharge from surface water bodies, and the effective groundwater reservoir is not to be seen. This is because groundwater withdrawal and recovery are balanced. The subsequent higher groundwater productions from the WSS intake well or withdrawal of water from the aquifer by new intakes outside can unbalance the groundwater environment equilibrium.

2ndStage: This stage can occur when annual rainfall drops and deviate from the average yearly rainfall of the recharging area. Therefore, withdrawal of groundwater must be performed by giving due attention to the

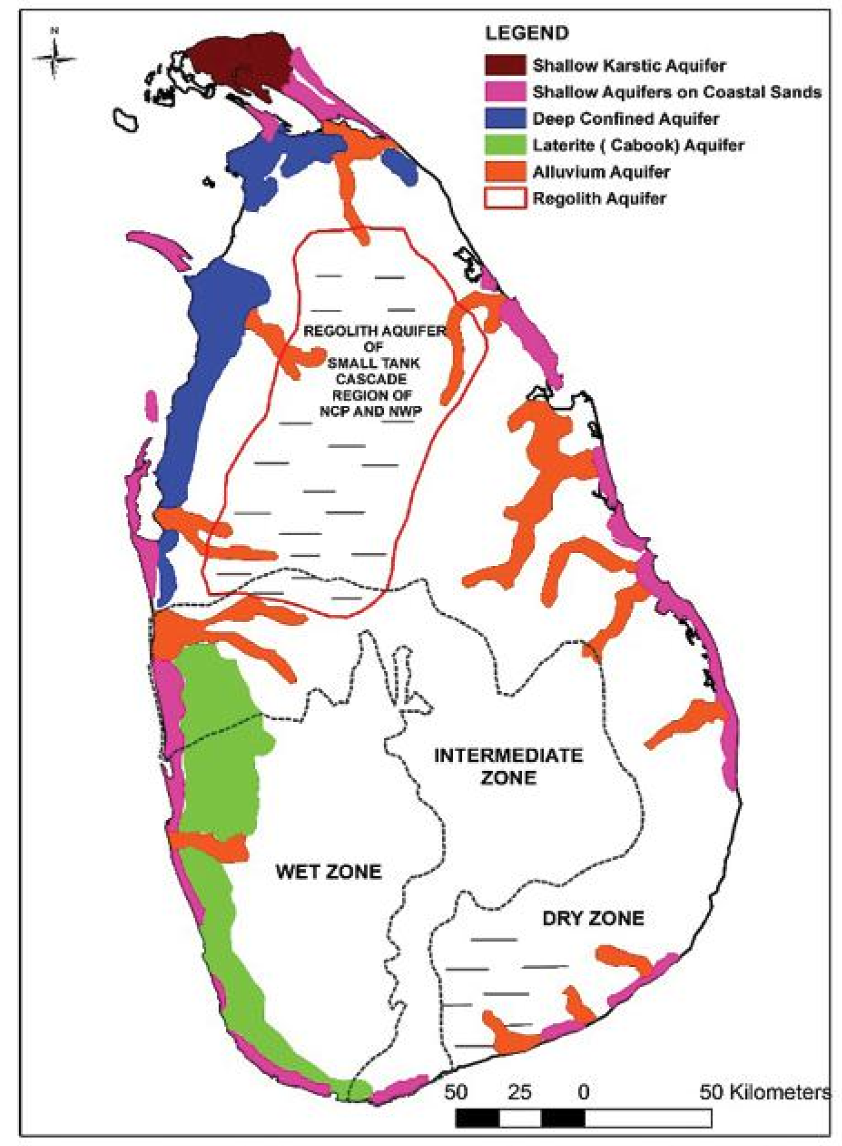

Figure (1): Groundwater level behavior during pumping

climatic conditions in order to protect the groundwater sources in terms of quality and quantity. Under this situation, groundwater recharge to the pumping well could drop and groundwater extraction from the pumping well must be regulated to balance recharge and protect the groundwater environment. In this stage, re-evaluation of the groundwater system is essential and groundwater pumping from the existing intake well needs to be rescheduled with new and appropriate discharges. Further, additional wells can be constructed in the areas where there is no interference to the existing pumping wells, to meet the water shortage. It is also necessary to study the possibilities to improve the aquifer system (artificial recharge) and to explore alternative water sources.

3rdStage: If groundwater development is continued disregarding the indications, the groundwater environment reaches the 3rdstage (reduction of groundwater storage and well yield, and changes in chemical water quality). There will be no provision for the restoration of the groundwater environment naturally. The only solution is introducing an artificial recharging system to improve the groundwater storage within the aquifer system which again depends on the vulnerability of the site.

Well design and intake construction affect the groundwater extraction

Some well problems are directly related to the construction weaknesses. They are sand yielding to the well through an theinterface between rock and overburden or/and screens or fractures, rock falling to the well, and entrance velocity issues due to the use of improper screen materials for the well. Therefore, suitable intake design and appropriate construction methods should be selected for maximum utilization of the aquifer and to control the well and aquifer pollution as per the hydrogeological conditions of the site.

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