The current status of sanitation and groundwater linkage in the city of Addis Ababa, Ethiopia

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General overview

Addis Ababa was established as the capital city of Ethiopia in 1886 and has grown to become the largest urban and commercial center in the country, hosting over 4.5 million residents. It is located in the central part of the country at the edge of the Ethiopian Rift. Addis Ababa is the seat of the African Union and other many international organizations.

Fast population growth and rapid industrialization, on one hand, and poor sanitation, on the other, have led to the deterioration of the ground water quality in the city of Addis Ababa due to direct linkage with the streams of the city. Previous studies such as Alemayehu and Vernier, 2000; Alemayehu, 2001; Alemayehu et al, 2005; Abiye 2008; Adelana et al, 2008; Abiye et al, 2008 showed poor groundwater quality in the city due to poor sanitation.

The exponential population growth in the city has lead to further groundwater exploration in different localities. It has been estimated that per capita consumption of water will approximately be doubled over the next 15 years as a result of several factors including improved living conditions with a greater proportion of backyard plantation and sanitary facilities; good personal hygiene; increase in commercial and industrial demand. Hence, the current demand has created a supply shortfall of over 50%. There are also continuous efforts by the municipality to establish new well fields to fill the existing water demand gap. Currently the main groundwater extraction is undertaken from Akaki well field (Fig. 2) and there are over 600 boreholes in the city (Fig.3) that tap partially polluted volcanic aquifer with the rate of 120,000 m^3/day.

The spatial water sampling has been carried out in the streams that drain the city. Random sampling on boreholes has also been performed. The results indicate that the impact of poor sanitation is high on groundwater. In the areas where sanitation is improved, the groundwater quality is relatively good. The groundwater vulnerability for pollution mapping performed has been done using DRASTIC model.

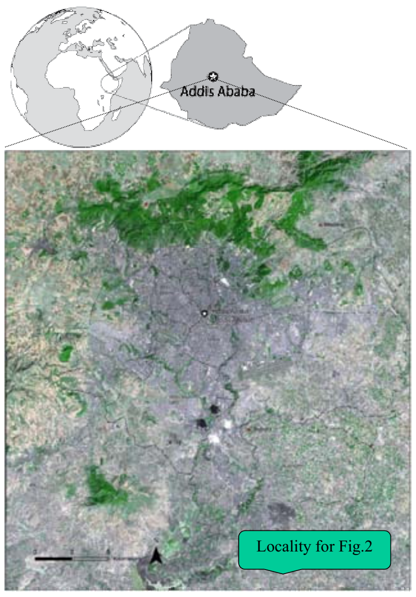

Figure 1. Location of Addis Ababa. The lower Landsat image shows topography and urban coverage

Figure 2. Unprotected Akaki well-field

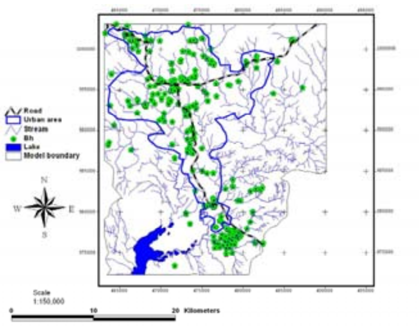

Figure 3. River network and some water supply boreholes

Sanitation

The urban wastewater is discharged largely into streams that drain the city. Only less than 3% join the wastewater treatment facilities. Since sanitation is one of the most basic services in human life, public toilets have been introduced with charge system in the city. However, most of the residents discharge directly into the nearby streams where over 35% uses septic tanks. The Kaliti Treatment Plant receives about 7,500 m^3/d of sewage from the city which is negligible amount for the city. This reaches a peak value of 10, 000 m^3/d at rainy seasons. The sewage collected using vacuum trucks from septic tanks is being discharged into drying beds that are constructed near the Kaliti waste stabilization pond and in Kotebe Yerer Ber.

Groundwater pollution

Polluted rivers due to poor sanitation (Figs 4, 6 & 6) pose a risk on the groundwater in the fractured and weathered volcanic aquifer of the city. This is witnessed by rapid fluctuation of faecal coliform and E. Coli (Fig. 7), pH (Fig. 8) and TDS (Fig. 9) in the groundwater. Monitoring results revealed that shallow unconfined groundwater shows fast change for contaminant input. Rivers that drain the city contain very low DO (Fig. 10) –categorized as dead rivers- due high biological oxygen demand wastes. In the city, the high level of groundwater pollution reduces its quality for different uses.

Figure 4. Poorly managed landfill

Figure 5. Polluted rivers by the domestic and industrial wastes

Figure 6. Daily activities in the polluted rivers

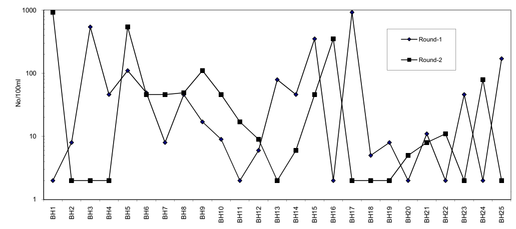

Figure. 7 Bacterial population in the groundwater

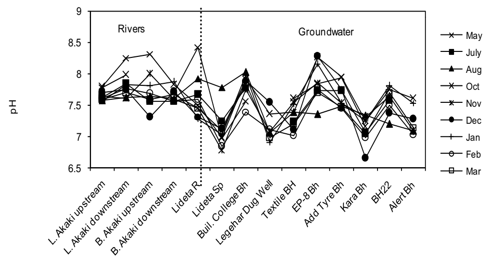

Figure 8 pH monitoring for surface water and groundwater

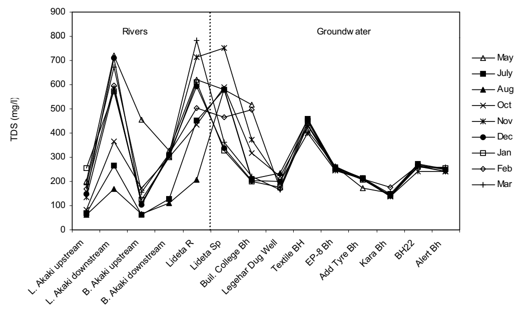

Figure 9. TDS monitoring for surface and ground water

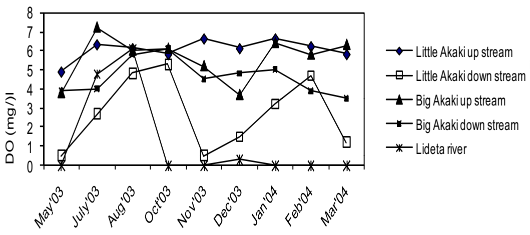

Figure 10. Dissolved oxygen monitoring in the river

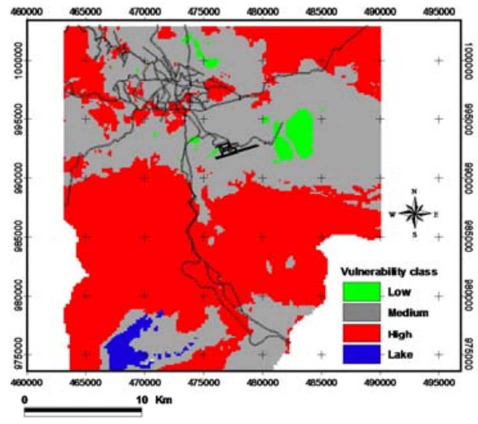

Figure 11. Intrinsic groundwater vulnerability to pollution map

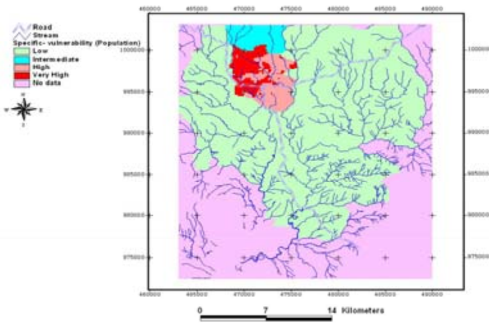

Figure 12. Specific vulnerability of groundwater for population

The plots show that slight variation in the quality of surface water due to poor sanitation is being reflected on shallow groundwater. The monitoring results revealed that the measures that help to improve the quality of surface water through proper sanitation could help to improve the groundwater quality.

The groundwater vulnerability to pollution map (Fig. 11) indicates that over 95% of the volcanic aquifer fall under highly vulnerable category that corresponds to the aquifer that contain large number of Faecal coliform and E. Coli bacteria. The main impact on groundwater is posed from highly populated part of the city (Fig. 12) where there is no any sanitary facility.

Conclusion

The provision of communal sanitary facility and affordable sewerage network could help to protect the vital water supply aquifer of the city from pollution which is generated due to poor sanitation.

References

Tamiru Alemayehu and Antonio Vernier (2000). Preliminary observation on urbanization as a risk for water quality in Addis Ababa, Proceeding of the Italian Studies in Ethiopia, 25-29 Sept. 2000, Italian Cultural Institute, Addis Ababa, Ethiopia.

Tamiru Alemayehu (2001). The causes for the surface and groundwater quality deterioration in Addis Ababa. *4th Theoretical Chemistry workshop in Africa (TCWA). Nov 5-9, 2002 Addis Ababa, Ethiopia*

Tamiru Alemayehu (2001) The impact of uncontrolled waste disposal on surface water quality in Addis Ababa. SINET: Ethiopian Journal of Science 24(1):93-104

Tamiru Alemayehu, Dagnachew Legesse, Tenalem Ayenew (2005). Hydrogeology, water quality and the degree of groundwater vulnerability to pollution in Addis Ababa. p125 Sept. 2005

Tamiru Alemayehu Abiye, Legesse,D., Ayenew, T., Watenigus, S., and Mohammed., N (2006). Degree of groundwater vulnerability to pollution in Addis Ababa. In the "Groundwater pollution in Africa". Editors Xu and Usher, Taylor and Francis, p 203-212.

Tamiru Alemayehu Abiye (2008). Urban groundwater pollution in Ethiopia. In " Applied groundwater studies in Africa" Editors: Adelana, MacDonalds, Alemayehu and Tindigumwa. Taylor and Francis, p360.

Adelana S., Tamiru Alemayehu, Nkhuwa D.C.W., Tindimugaya C and Oga M.S (2008). Urban groundwater management and protection in Sub-saharan Africa. In " *Applied groundwater studies in Africa"* Editors: Adelana, MacDonalds, Alemayehu and Tindigumwa.P231-260 Taylor and Francis, USA, p360.

Tamiru Alemayehu Abiye, Hameed Suleiman, Michael Ayalew (2008). Use of treated wastewater for Managed Aquifer Recharge in highly populated urban centers: a case study in Addis Ababa, Ethiopia. Environmental Geology Journal (DOI 10.1007/s00254-008-1490-y)

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