25th WEDC Conference Addis Ababa, Ethiopia, 1999

INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION

Pollution of the hydrogeologic system of Dire Dawa

Taye Alemayehu, Ethiopia

DIRE DAWA HAS remained the main fast growing city in Eastern Ethiopia. Its fast growth rate as an industrial and commercial center, lack of proper sewers and other waste disposal facilities, presence of about 20,000 open pit latrines, favorable geological, morphological, climatological and conditions have facilitated pollution of the hydrogeologic system. In this city there has been shortage of water and population increases at a higher rate. In 1965 population was only 23.33per cent of that of today's but after only three decades, in 2030, it is predicted to grow by 3.73 times.

Apart from the future danger of possible water shortage, the quality of ground water storage is questionable. The soft alluvium deposits, the main aquifers, has been polluted for the past ten decades by descending pollutants, which eventually reached the groundwater vertically and as far as Shinile town down stream. As a result there are excessive concentrations of nitrate, sulphate and chloride. The drop in water-table due to decrease in precipitation and over pumping is considerable.

Methods

To pinpoint reasons of pollution and reach in to convincing conclusion, 20 out of 50 boreholes, 4 out of 12 dug wells and 2 out of 4 springs which are found in the town and its vicinity are randomly sampled and analyzed. Population density of different zones of the town is correlated with degree of pollution. The geological, structural and hydrogeological characteristics of the surrounding rock formations is analyzed. Rainfall data which is recorded starting from 1931 and temperature records starting from 1951 is analyzed. The potential evapotransipiration is calculated from available recorded data. Finally, record of the largest hospital is taken to analyze impact of polluted water on residents. Different Organizations such as the Alemaya University of Agriculture, Ministry of Health and the City's manucipality are consulted for possible impact of pollution on their activities.

Results and discussion

The dominant lithology is the Mesozoic sedimentary deposit consisting limestone, sandstone, shale, and chalk. Most part of the plain is covered by loose & recent superficial deposits consisting sand, silt, clay, river gravels, fans and travertine with considerable thickness.

Joints of tectonic origin, faulting and fracturing are dominant structural features in the area. The Mesozoic sediments are major aquifers in the area with high discharge. The nature of structures has increased the quality of aquifers. Static water level measurement at different time intervals reveal a decrease in the ground-water table. Ground water table drop up to twelve meters is measured in twelve various wells, between the year 1960-88.

Volume of ground water storage is $12.9x10^9M^3$ in the 400m thick alluvial plain and $7.09x10^{9}M^3$ in the 150m thick escarpment zone (Tesfamichael, 1974). The rainfall pattern has decreasing trend. In the period 1931-37 and 1953-63 the average rainfall amount was 650 and the annual average figure for the period 1964-73 was 563mm, which is less by 103mm. The mean monthly temperature in the period 1951-70 was 24.2°C. This figure increased by 1°C in the coming years-1971-85. Accordingly, the potential evapotranspiration in the period 1951-70 was 1711.5mm. This figure increased by more than 40mm in the coming years 1971-85. Meanwhile, the amount of rainfall in the period between 1971-85 was minimum and is only about one-third of the total potential evapotranspiration. These factors have considerable impact in aggravating pollution by minimizing the dilution effect by decreasing precipitation and increasing evapotranspiration.

From records found from the Out Patient Department Of Dire Dawa Hospital, 10 out of 15 most common diseases are directly or indirectly related to water. Among the top 15 diseases, duodenitis and gastritis and kidney infection ranks 4th and 13th respectively. The presence of the methemoglobinemia or blue baby disease, a killer disease caused by drinking water with high nitrate concentration and that affects infants, case is unknown. The health workers are unaware of water pollution in the city. In fact the public water source is safe for domestic consumption, but still people might use sources outside the public water supply.

The source of contamination of the hydrogeologic system are two types. The first and dangerous one is the point source contamination , which is caused by more than 20,000 unprotected pit latrines found in the city. These latrines carry the human excreta to the hydrogeologic system through the loose formation. The second source of contamination is the line source contamination caused by the discharge of enormous amount industrial and domestic waste water (Table 1) into the sandy stream channels. This effluent percolate within few hundreds of meters distance from their sources. Chemical analysis carried on two waste drainages, in Textile and Soft Drinks Factories, shows extremely high total dissolved solids. The textile mills

discharge waste water has a TDS value of 7500mg/l. Sodium, chloride and sulphate are the most abundant components.

From the overall analysis of available data of almost 30 years period total dissolved solids reveals alarming increase. In wells located at the heart of the town ten fold increase in TDS from that of 30 years back is measured. Most wells show two to three fold increase. The degree of hardness in all waters of the city is very hard; all have values greater than 300mg/l.

Trend analysis of past years record shows a growing calcium ion concentration which is mainly caused by the drop in the amount of annual precipitation within and outside the basin. The content of bicarbonate ion is also not suitable for food processing.

The concentration of chloride in some water points is more than 700 mg/l and the trend is growing. Sulfate is increasing at an alarming rate. The value of sulfate in most water points in 1959 was less than 100mg/l. After 30 years most wells have values greater than 200mg/l value. Some localities show up to three fold increase. The source of sulfate is mostly the human excreta and sewage.

Similar to sulphate nitrate concentration is fast growing and thus potentially dangerous. In 1959, the maximum concentration record was only 45 mg/l at the heart of the city. Value measured in 1982 was as high as 320mg/l in a

Table 1. Predicted comparison of water use and waste water production.

Year	Population	Total Water Demand[1]		Domestic Consumption[2]		Amount of Domestic Waste[3]	
		l/c/d	ml/yr	l/c/d	ml/yr	l/c/d	ml/yr
1982*	86,000	42.5	1334	21.3	667	14.9	468
1995	169,793	77	4772	38.5	2113	27	1502.8
1998*	192,070	78	5475	39	2738	27.3	1917
2000	208,543	86	6553	43	3277	30.1	2293
2010	313,682	126	14438	63	7219	44.1	5053
2020	474,842	166	28788	83	14394	58.1	10076

* Actual Figures 1. Computed considering an average 4 l/c/d increment per year water demand 3 Estimated at 70% of the total domestic consumption 2 Estimated at 50% of the total

Table 2. Groundwater quality change in time (selected water sources)

Name of water point	TDS/mg/l/			Hardness as $CaCO_3$			Nitrate		Sulphate			Chloride		
	1960	1974	1988	1960	1974	1988	1960	1982	1960	1974	1988	1960	1974	1988
Cotton Factory Bh1	-	-	500	-	568	661	-	-	-	169	411	-	-	-
Cotton Factory Bh2	854	987	2500	520	512	629	trace	62	100	136	205	106	175	177
Cotton Factory Bh39	-	-	400	-	505	704	-	86	-	-	288	-	-	132
High Way Bh	946	721	1000	360	455	716	45	110	60	56	82	53	78	709
Dire Dawa Hosp. Bh	460	1497	3500	240	1019	920	45	-	60	22	164	46	57	354
Tony Farm HDW	-	840	989	-	384	373	-	49	-	67	205	-	78	155
Chandris HDW	698	957	2500	461	456	526	trace	48	60	59	41	46	60	132
Ras Hotel HDW	344	911	1371	240	500	965	35	-	40	32	205	18	135	709
Lege Hare Spring	486	772	1020	240	445	640	45	38	60	74	41	53	107	496

Source: Various Sources Bh - Borehole HDW- hand dug well

similar well. Many wells shows more than two fold increase in two decades. (Table 2).

Conclusion

From the over all analysis made, it is concluded that, the rainfall pattern, over-pumping and depletion of recharge from the highlands, as indicated by the recent drop in water table, is making the groundwater storage non-dependable. Most of all the degradation of the main groundwater storage, mainly by human activities, will leave the city without any near by possible source of water supply in the future.

Sewage related pollution already has manifested itself in drinking and food processing water and with increasing volumes of water use and pollutant disposal, it is likely to occur at increasing amounts in the future,. Irrigation east and west of the city and some geologic formations like caleche formation are part of the problems for high nitrate values. The way human excreta has been disposed for almost a century is the main reason for the current high nitrate concentration. Degree of pollution is directly related with population density and groundwater flow direction. While the most precious natural resource, water, is polluted in such a way no state measure is taken to protect the hydrogeologic environment. Therefore, government's political, ecological and moral responsibility for the protection of ground water is inescapable. Modification in the master plan of the city, to protect safe zones of the basin and the construction of pit latrines using impermeable casings, and bottom lining by concrete and construction of swage system and strong environmental monitoring have paramount importance to control further aggravation of the problem.

Reference

CSA, 1995. *The 1994 population and Housing Census of Ethiopia*, Oct. 1995 Addis Ababa.

ASSOCIATED ENGINEERING SURVEY LTD. Oct. 1982. *Dire Dawa Feasibility study for Water Supply*.

KETEMA TADESSE, 1982. *Hydrogeology of the Dire Dawa Area*. EIGS, Addis Ababa.

MEZMURE HAILEMESKEL, 1980. *Report on well construction and pumping test*. EIGS, Addis Ababa.

TESFAMICHAEL KELETA, 1974. Unpublished Report No. 11, *Hydrogeology of Dire Dawa Area, A statement of present knowledge*. EIGS, Addis Ababa.

UARK W.JOHN AND WARREN VIESSMAN. 1970. *Water Supply and Pollution control*.

GREITZER YESHAYEHU, 1970. *Stratigraphy, Hydrogeology and Jurassic Communities of the Harar and Dire Dawa Area*. EIGS, Addis Ababa.

TAYE H. ALEMAYEHU, Oromia Water, Mineral and Energy Resources Development Bureau.