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Urban water pollution and irrigated vegetable farming in Addis Ababa

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Water pollution can be considered as a side-effect of economic growth and is a common phenomenon in fast growing cities in developing countries. This paper describes the situation in Addis Ababa by tracing the origins of pollution and by focusing on urban and peri-urban farmers who depend on polluted water sources for irrigated agriculture. Discharge of untreated effluent from industries, solid wastes and wastewater from households and institutions, are the major sources of pollution of the rivers flowing through the city. For existing industries, pollution control mechanisms such as discharge permits and limits to the disposal of effluents into the environment should be enforced. The local and state governments should enhance public sensitization programs on hygiene, sanitation and environmental issues.

Introduction

Fast population growth and inadequate sanitation infrastructure are causing serious environment pollution problem in and around Addis Ababa. The main water resources that provide the city with water are *Geferssa*, *Legedadi* and *Dire Dams* having a combined daily production of 173,000 m^3. Additional supply comes from 20 major springs (10,000 m^3day^{-1}) and the Akaki well system (~30,000 m^3day^{-1}) (AAWSA, 2000). Two major rivers flow through the city, namely *Tinishu Akaki* (Little Akaki) and *Tiliku Akaki* (Great Akaki) Rivers. These rivers, which are tributaries of *Awash* River, originate from *Entoto Mountains* that are located north to Addis Ababa and flow to *Aba Samuel* Lake (43 km to the South). The rivers serve as drains for excessive stormwater and the disposal of domestic and industrial wastewater (AAEPA, *Unpub*, Chekole, 2006). Water from the rivers is being used for various purposes; irrigation, sand mining, industrial consumption, washing of materials, and bathing, cattle consumption and waste disposal. Irrigation is a visible water use practice in the city. According to the local Urban Agriculture Office, an estimated 1,574 farmers (28% women) are working on a total farm area of 400ha throughout Addis. All of them are irrigating with Akaki River water through surface irrigation, with or without the use of a pump. Irrigated vegetable production accounts for about 60% of the total market supply for the city (UAO, 2002). Table 1 shows the vegetables and the income derived from the irrigation.

The next section provides a brief overview of the current state of water pollution, a brief description of the impact of water pollution on human health, with some conclusions and recommendations will be given in the last section of this paper.

Current state and trends of water pollution

Sources of water pollution

The main sources of pollution that enters urban surface water bodies are industries, municipal solid waste and oily wastes from garages and fuel stations. There are over 2,000 registered industries in Addis Ababa (65 % of all industries in the country) most of them located along the river banks. According to the Addis Ababa Environmental Pollution Authority (2007, unpublished), 90% of all industries lack facilities for some degree of on site treatment plant, and subsequently discharge any effluents into a adjacent streams.

According to the Sanitation Beautification and Parks Development Agency, a city total of 2,256 m^3 or 851 tonnes of solid waste is being generated daily of which 65% is collected and disposed in to *Repi* dump site, about 10 % of the waste is composted and recycled while the remaining 25% is dumped into open spaces, ditches and water bodies (CGASBPDA, 2003). In addition to solid waste, domestic wastewater is a major contributor to water pollution in Addis Ababa. According to a World Bank report (2007a), an estimated one quarter of the households in Addis lack any form of sanitation facility and as a consequence they use open spaces, shrubs and river banks to relieve themselves.

Table 1. Type of vegetables and income derived from irrigated agriculture in Addis Ababa.

Vegetable	Plot size (ha)	Market price (birr/kg)	Net income (birr/ha)	Total net income (birr/year)	Av. farmer income (birr/month)
Lettuce	55	2.00	24,279	2,666,805	141.2
Swiss Chard	49	2.00	21,810	1,060,620	56.2
Carrot	46	1.00	14,854	1,363,597	72.2
Cabbage	33	1.00	24,425	1,591,045	84.2
Kale	39	2.00	9,269	724,094	38.3
Potato	49	1.00	11,915	1,160,521	61.4
Beetroot	25	1.00	22,010	1,113,706	59.0
Tomato	15	1.25	14,735	442,919	23.5
Onion	7	2.00	12,960	181,440	9.6
Pepper	6	2.50	5,442	62,583	3.3
Leek	16	2.00	14,585	466,720	24.7
Pumpkin	4	1.00	31,550	113,580	6.0
Cucumber (Zukuni)	10	2.00	65,660	1,353,909	71.7
Phaseolus (bean)	10	2.50	3,193	65,574	3.5
Cauliflower	27	3.00	14,070	747,398	39.6
Total	**390**	**26.25**	**290,756**	**13,114,512**	**694.4**

Note: US$ = 11 ethiopian Birr

Source: Bureau of Agriculture Addis Ababa, 2003

Little and Great Akaki Rivers

Based on the Slovak Technical Standard grade system (STN, 1998) and WHO drinking water guideline (2004), the water quality of the Little and Great Akaki river basins have been classified as badly polluted to very badly polluted water (Grade IV to V). Obviously, in neither of the grade categories, is the water suitable for drinking. Table 2 shows the comparison of water quality of the main rivers in Addis to that of Slovak Technical Standard and WHO drinking water quality guidelines. The presence of trace metals in the tested samples indicates that industries have a significant contribution to surface water pollution. The presence of high concentrations of *E. coli* bacteria in the samples indicates fecal matter pollution.

Table 2. Comparison of water quality characteristics of Little and Great Akaki River with WHO and STN (Mersha, 2008)

	Little Akaki	Great Akaki		
Parameter	**Mean ±95%CI (mg l^{-1})**	**Mean ±95%CI (mg l^{-1})**	**WHO* (mg l^{-1})**	**STN Classification (1998)**
pH	7.6±0.08	7.7±0.4	6.5-8.5	Very clean water (I)
DO	3.02±0.86	3.1±2.7	-	Badly polluted water (IV)
BOD	130±171	111.5±244	-	V. Badly polluted water (V)
COD	354.8±434	566.4±1301	-	V. Badly polluted water (V)
NO_3^-	7.59±10.8	10.5±8.4	50	Badly polluted water (IV)
PO_4^{3-}	3.94±2.3	4±0.77	-	-
Cd	0.009±0.003	0.0076±0.01	0.003	Polluted water (III)
Cr	0.029±0.03	0.09±0.05	0.05	Clean water (II)
Pb	0.028±0.05	0.069±0.12	0.01	P-B polluted water (III-IV)
Co	0.048±0.03	0.067±0.05	-	P-B polluted water (III-IV)
E.Coli (CFU $100ml^{-1}$)	$6.68*10^9$	$6.61*10^9$	0	V. Badly polluted water (V)

* Maximum Allowable Value

Impact of water pollution on human health

Polluted water bears two kinds of economic costs: firstly, pollution reduces the total amount of adequate water available for household consumption or agricultural and industrial usage. Thus, there are economic costs of water held back from supply. Secondly, there are costs related to the use of polluted water for consumption and production. The costs of using contaminated water for production refers to the decrease in both quality and quantity of products (World Bank, 2007b). Water pollution may damage aquatic populations such as fish, shrimps and crabs. Although there are no data available for types and quantity of fish species in the rivers of Addis Ababa, the name "Kurtume[1]" has been found in old literature, which suggests that once there was fish present in the Great Akaki River and its tributaries.

Biological pollutants and their health effects

Biological pollutants may consist of micro-organisms which can cause diseases such as hepatitis A or E, dysentery, typhoid fever, cholera and diarrhoea. Diarrhoea and viral hepatitis, both associated with faecal pollution, have been the leading infectious diseases in the last two decades. Table 3 and 4 show the top ten leading causes of outpatient and admission cases in Addis Ababa and Ethiopia (MOH, 2005). It is noted that diarrhoea alone is responsible for 212,809 outpatient cases throughout the country and typhoid fever is the cause of 14,913 cases of out patient, admission and deaths in Addis Ababa.

Calculating the public health implications of water pollution proves difficult for several reasons. Firstly, there are only a limited number of studies available at national or Addis Ababa level. Secondly, the epidemiology of water pollution and its application is limited due to the fact that there are other possible factors that could contribute to a disease besides polluted water. Food, smoking, occupational exposure and air pollution may also cause health problems, which makes measuring the extent to which water pollution is the cause of health problems difficult. Despite this fact an effort was made to calculate the cost required for a

[1] In the indigenous *Oromiffa* language, “Kurtume” means fish.

diarrhoea disease treatment in Addis Ababa. Depending on a public or private health treatment facility, a patient is expected to pay 16-36 ETB ($1.45 - $3.30) per treatment. If we multiply this figure by the total number of diarrhea cases, we find that the country spends between 3.4 and 7.7 million Ethiopian Birr (0.31→ 0.7 million US$) on diarrhoea treatment. It is to be noted that the estimation does not include other economic losses such as time and loss of earnings due to absence from the jobs.

Table 3. Annual outpatient cases

No.	Disease/ Diagnosis	Cases	Level
1.	Diarrhoea	212,809	National Level
2.	Helminthes	55,970	National Level
3.	Dysentery	32,503	National Level
4.	Typhoid Fever	14,668	Addis Ababa
5.	Diarrhoea with blood	8,928	Addis Ababa
6.	Diarrhoea with sever dehydration (< 5 yrs)	10,639	Addis Ababa

Source: 2004/2005 Ethiopian Ministry of Health

Table 4. Annual outpatient cases

No.	Disease/ Diagnosis	Cases/Deaths	Level
1.	Typhoid Fever	244/1	Addis Ababa
2.	Diarrhoea with blood	208/3	Addis Ababa
3.	Diarrhoea with sever dehydration (< 5 yrs)	4,036/72	Addis Ababa
4.	Diarrhoea with some dehydration (< 5 years)	1,123/13	Addis Ababa

Source: 2004/2005 Ethiopian Ministry of Health

Chemical pollutants and their health effects

Table 5 shows the concentration of trace metals in vegetables that were grown with wastewater. The high concentrations of Cadmium, Chromium, Copper, Mercury, Nickel and Zinc give evidence of industrial pollution traced back in agricultural crops. Long-term exposure to low levels of chemical pollutants can lead to chronic health effects and enhance the risk of adverse pregnancy outcomes. Empirical evidence shows a strong association between drinking water pollution and cancer incidence and mortality.

Even though all of these metals have not yet reached the phytotoxic levels, some of the vegetables have surpassed the naturally expected levels. This is particularly true for Cd, Cr, Cu, Hg, Ni and Zn in potato and Cr in onion and red beet. For a long time, it has been known that intake of food that contains high levels of heavy metals, poses risks to human health (Pendias & Pendias, 1984).

Conclusions

The discharge of untreated effluent, solid wastes and wastewater from industries, households and institutions are the main sources of water pollution in Addis Ababa. Water pollution due to fecal matter contamination and poor sanitation practice may be the major cause of the top ten leading causes of out patient visit, hospital admission and death among children and elderly, in Ethiopia in general and Addis Ababa city in particular. Water pollution does not only have adverse health impacts but it also imposes medical expenses to the population which does not help fighting urban poverty. It is likely that in earlier times, the rivers flowing through Addis contained fish. Water pollution is likely to have contributed to the disappearance of aquatic species. A lack of incorporation of environmental issues in future water development activities can lead to

social and environmental pollution problems which in return pose a burden on the human health of Addis' residents and may demand huge resources when the need is there to clean up the pollution.

Table 5. Trace metal content in vegetable leafs in Addis Ababa (Itanna, 1998).

Vegetable	Metal content (mg kg^{-1})						
	As	Cd	Cr	Cu	Hg	Ni	Zn
Cabbage	0.105	0.030	1.80	3.28	0.218	0.64	29.7
Onion	0.105	0.018	2.81	5.24	0.201	0.44	15.4
Potato	0.113	0.076	2.26	8.72	0.355	1.75	47.4
Red Beet	0.170	0.057	2.87	8.92	0.142	1.47	27.3
Swiss Chard	0.038	0.044	1.25	8.96	0.218	0.79	38.1
WHO Standard	*0.50*	*0.10*	*5.0*	-	*0.05*	-	*15*

Recommendations

In order to minimize the ill effects of industries on the environment mainly on water bodies, it is essential to enforce the carrying out of an Environmental Impact Assessment prior to the approval of any new development projects, programmes or policies. Promotion of cleaner technologies such as cleaner industrial production will help industries not only to minimize their wastes but will also to save resources (water and money) and reduce their impact on the recipient environment. For existing industries, it is important to put in place industrial pollution control mechanisms such as environmental auditing, discharge permit and enforce limits to the disposal of effluents into the environment. Activities such as car washing and fuel stations that discharge waste oil and other wastes that have environmental impact should become submissive to environmental pollution control. Environmental pollution can also be minimized through providing economic incentives for industries to introduce innovative pollution control measures in their production process. In order to improve the current solid and waste water management practices it is important to establish integrated solid and wastewater management that considers technical, legal administrative, financial and social aspects. A more detailed study on the socio-economic impacts of water pollution in Addis Ababa is desired. The local and state governments should enhance public sensitization programs on hygiene, sanitation and environmental issues.

References

AAEPA. Estimation of Pollution in Little and Great Akaki Rivers. *Unpublished Report*. Addis Ababa Environmental Protection Authority. Addis Ababa

CGASBPDA (2003) Solid Waste Management Status Report of Addis Ababa: The Way Forward. City Government of Addis Ababa Sanitation Beautification and Parks Development Agency. Addis Ababa.

Chekole ZF. (2006) Controlling the informal sector. Solid waste collection and the Addis Ababa City Administration, 2003-2005. Department of Geography. Trondheim, Norwegian University of Science and Technology**:** 125.

Itanna F. (1998) Metal concentrations of some vegetables irrigated with industrial liquid waste at Akaki, Ethiopia. *Ethiopian Journal of Science 96* **Vol. 21**(No. 1): 133 - 144.

Mersha Z. (2008) Water Quality Monitoring Design for Little Akaki River. U*npublished M.Sc.* thesis. Addis Ababa University. Addis Ababa.

Pendias, A.K., and Pendias, H. (1984). Trace elements in Soils and Plants. CRC Press, Inc., Boca Raton, Florida

STN (1998) Technical Guideline for surface water bodies. Slovak Technical Standard. Bratislava

UAO (2002) Unpublished Report. Urban Agricultural Office of Addis Ababa City Government. Addis Ababa

World Bank. (2007a) *Project appraisal document on a proposed credit to Ethiopia for an Urban Water Supply and Sanitation Project*. Washington.
World Bank (2007b) Cost of Pollution in China. Beijing: World Bank. Retrieved on February 23, 2008 from http://siteresources.worldbank.org/INTEAPREGTOPENVIRONMENT/Resources/China_Cost_of_Pollution.pdf

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