PROGRAMME ON SUSTAINABLE CONSUMPTION AND PRODUCTION IN THE AKAKI RIVER BASIN

A Situation Analysis of the Akaki River

Final Report

The Ethiopian Science and Technology Comission (ESTC)
United Nations Environment Programme (UNEP)
And The Ethiopian Cleaner Production Center (ECPC)

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ACRONYMS AND ABBREVIATIONS

AAEPA	ADDIS ABABA ENVIRONMENTAL PROTECTION AUTHORITY
AAU	ADDIS ABABA UNIVERSITY
AAWSA	ADDIS ABABA WATER AND SEWAGE AUTHORITY
ABWRAA	AWASH BASIN WATER RESOURCES ADMINISTRATION AGENCY
AWTI	ARBA MINCH WATER TECHNOLOGY INSTITUTE
ECPC	ETHIOPIAN CLEANER PRODUCTION CENTER
EGS	ETHIOPIAN GEOLOGICAL SURVEY
EnDA	ENVIRONMENT DEVELOPMENT ACTION
ENHRI	ETHIOPIAN HEALTH NUTIRITION RESEARCH INSTITUTE
EPA	FEDERAL ENVIRONMENTAL PROTECTION AUTHORITY
ESTC	ETHIOPIAN SCIENCE AND TECHNOLOGY COMMISSION
EVDSA	ETHIOPIAN VALLEYS DEVELOPMENT STUDY AUTHORITY
JU	JIMMA UNIVERSITY
MoFED	MINISTERY OF FINANCE AND ECONOMIC DEVELOPMENT
MoH	MINISTRY OF HEALTH
MoM	MINISTRY OF MINES
MoTI	MINISTRY OF TRADE AND INDUSTRY
MoWR	MINISTRY OF WATER RESOURCES
OEPO	OROMIA ENVIRONMENTAL PROTECTION OFFICE
QSAE	QUALITY AND STANDARDS AUTHORITY FOR ETHIOPIA
UNEP	UNITED NATIONS ENVIRONMENT PROGRAM
UNIDO	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
WHO	WORLD HEALTH ORGANIZATION
WWDSE	WATER WORKS DESIGN AND SUPERVISION ENTERPRISE

EXECUTIVE SUMMARY

Context

In several regions of Ethiopia, a rapidly increasing population, together with widespread activities in the agricultural and manufacturing sectors, has brought about the depletion and pollution of natural resources. However, due to various socio-economic constraints facing the country and a widespread lack of awareness of environmental problems, this issue has not been given priority. As the most densely populated and industrialized Administrative Region in the country, the city of Addis Ababa and its surrounding, is most affected by both water and air pollution. The water pollution problem which is the focus of this report has been manifested by the deteriorating water quality of rivers draining through the city.

The Akaki River is the most important river that drains the basin in which the city of Addis Ababa is located. The River is being used for a variety of purposes, including drinking, irrigation (horticultural), cooking, hygiene (domestic) and industrial purposes. However, several studies conducted have shown that the river is gradually becoming highly unfit for these purposes. As a direct consequence of the degree of pollution, the River has very low dissolved oxygen for aquatic species to survive. This has thus created an urgent need to design and implement measures to improve the water quality of the River.

Aim of the Study

The purpose of this study is to provide comprehensive background information for initiatives that anticipate to design and implement pollution alleviation measures for improving the water quality of the Akaki River. The document incorporates information on the pollution status of the Akaki River and its socio-economic impacts. It also includes information on institutional, legislative and policy aspects that would be important when implementing water resources management programmes in the country. Finally the study identifies the role of the various stakeholders that could be partners for programme development and implementation of intervention measures.

Findings

- Almost all the research documents reviewed in this study show that both the Little and Great Akaki Rivers are highly polluted due to discharges from different activities that include industries, households, hotels, garages, etc. Although updated figures are not available, household waste seems to be the major contributor for the pollution of the rivers. In fact the level of some pollutants indicates that there is a major reason for concern. This is clearly illustrated by the high level of pollutants in both the Little and Great Akaki.

- Comparison between the Great and Little Akaki reveals that the Little Akaki is more polluted. This is most probably a result of a large number of industries that are situated along the river. Most of these industries discharge their wastes directly into the river. Waste from densely populated area also enters streams that ultimately join the Little Akaki.

- The major implication of the pollution of the rivers is associated to water related health complications manifested in the population of Addis Ababa and the surrounding. Currently water related diseases are the major reason for high morbidity among the population in region. In fact in downstream locations (Oromia Regional State), where a substantial percentage of the population utilizes the river for drinking purposes, the problem is a reason for major concern. Studies have also shown the associated economic loss to be quite significant. In addition due to the high degree of pollution the rivers have very low dissolved oxygen that seriously impedes the survival of aquatic species.

- From an institutional perspective at the current period there is a conducive environment for monitoring the water quality of the Akaki Rivers. Several institutions are implementing mitigation measures to alleviate the degree of pollution of the rivers. A number of programs undertaken by the Addis Ababa Environmental Protection Authority, the Federal Environmental Protection Authority, Ministry of Water Resources, Oromia Water Bureau, Addis Ababa Water and Sewage Authority and the Awash Basin Water Resources Administration Agency are only some of the activities that are ongoing. Currently the Federal EPA and the Clean and Addis Ababa Society also have

similar initiatives on the Akaki and Kebena[1] River respectively. However, there are gaps and overlaps in the mandates and activities of some of these institutions that call for the coordination of ongoing commendable efforts.

- For the implementation of a successful integrated management plan for the Akaki, it is a prerequisite to involve a number of partners. This should involve institutions from different sectors including government, private sector, NGOs/CSOs and Donor Agenicies. However, mandated governmental institutions have the principal roles as they have the implementation capacity and responsibility to undertake such endeavors. In this regards the capacities and roles of the Federal Environmental Protection Authority and Regional Environmental Agencies, Ministry of Water Resources and Regional Water Bureaus, Ministry of Health and Regional Health Bureaus are elaborated in the report. Institutions that can assist in monitoring water quality include Addis Ababa University, Ethiopian Health and Nutrition Research Institute, Quality and Standards Authority and the Ethiopian Geological Survey of the Ministry of Mines. Their potential contribution has also been highlighted in the report.

[1] Kebena is a tributary of the Great Akaki River.

1. INTRODUCTION

Water has become a dominant resource issue in recent decades. According to recent estimates, around 10% of the world's population live in regions where there is chronic water shortage (Falkenmark, 1993; John Hopkins University, 1998). This figure is estimated to increase dramatically in the near future (Cunningham and Saigo, 2001). However, in many cases the problem is not the shortage in total water supply but the availability and access to clean, potable water (Falkenmark, 1991; Gardner-Outlaw and Engleman, 1997). Among the major problems that pose a serious threat to the availability of clean water is the pollution of water bodies by contaminants from various sources (Pandey, 1997).

The Awash Basin is situated in the east-central part of Ethiopia and constitutes the north-central part of the Ethiopian Rift Valley. Sandwiched between the northwestern and southeastern highlands, the basin is part of a predominantly hot and arid to semi-arid lowland region experiencing the effects of a rain shadow and documented water shortages (EDVSA and Halcrow, 1989). Over the last three decades there has been a dramatic increase in population density in this region. This, in conjunction with the widespread and accelerating activities in the fields of agriculture and industry, has brought about increased pollution of the Awash River and its tributaries. In turn the limited capacity to enforce regulations regarding the safety and protection of these rivers has aggravated the problem. In particular the headwaters, which are situated in and around Addis Ababa, are extremely polluted from domestic, commercial and industrial sources.

Among the important headwaters of the Awash is the Akaki River, which flows through the city of Addis Ababa. The river consists of two main branches, the confluence of which was the Aba-Samuel reservoir until recently. The western branch of the river, the Little Akaki, rises northwest of Addis Ababa on the slopes of Wechacha Mountain and flows for 40 km before it reaches the reservoir. Tributaries of the Little Akaki include Burayu, Gefersa, Leku, Qille, Gerbeja, Worenchiti, Melka Qorani, Kera and Jaja streams.

The eastern branch of the river, the Great Akaki, rises northeast of Addis Ababa and flows into Aba-Samuel Reservoir after 53 km. The important tributaries of the Great Akaki include Ginfile, Kebena, Kechene, Kurtume and Yeka. Both the Akaki Rivers are used for industrial, horticultural and domestic purposes. Unfortunately, these rivers are also used as disposal sites for the waste generated by industries and other sources from the city of Addis Ababa and its surrounding.

Currently, the pollution load on both Akaki Rivers has risen so high that the rivers, in particular the Little Akaki has deteriorated to the status of an open sewer. Populations utilizing these rivers for drinking and probably hygiene and horticultural purposes are affected by a variety of health complications. Chronic health risks exist in people consuming vegetables produced using these rivers for irrigation. Furthermore their ecology has been so disrupted that they have essentially become *'dead rivers'* (Kolmorit and Firdu 1974, Tamiru 2000).

As a result of a dramatic increase in population and the consequent demand for water, the government anticipates to utilize local groundwater sources (the Akaki well fields) situated in the vicinity (Figure 2). However, unless stringent measures are soon undertaken to improve surface water quality, seepage from the polluted rivers and runoff will ultimately affect the groundwater, which is an alternative potential for supplying clean water in the region. In fact currently the pollution of surface and groundwater is one of the most serious problems affecting the health of the population in and around Addis Ababa (Tamiru et al 2004).

The Akaki River Initiative is an outcome of the African Roundtable on Sustainable Consumption and Production, a programme initiated and supported by the United Nations Environmental Programme (UNEP). Through this programme UNEP, together with National African Cleaner Production Centres, undertakes activities to introduce and promote cleaner production techniques and technologies. Expanding on this activity, the Ethiopian Cleaner Production Centre (ECPC) and UNEP started an initiative that anticipates to develop a framework for an integrated management plan of the Akaki, the most polluted river in Ethiopia.

So far, various institutions and researchers have addressed the issues related to the pollution of the Akaki River. However, it is recognized that the scope of the problem requires a much more consolidated and comprehensive approach that needs to be developed and implemented through a broad-based partnership. The main aim of the Akaki River Initiative is thus to increase the level of awareness among planners, city administrators and the general population with regard to the pollution of the river and create a framework that will enable concrete actions to be taken.

This study aims to present a situation analysis of the Akaki River that will provide a basis for developing an "Integrated Management Programme for the Akaki River". This document will incorporate the following assessment including:

- The current pollution status of the Akaki River and the major sources of the pollutants;
- The socio-economic impact of the pollution;
- On-going programmes and planned activities to alleviate the problem;
- The pertinent policy issues and institutional arrangements in water resources management;
- Capacities and gaps in the current water resources management programme of the country and;
- The identification of stakeholders that could be partners for the development and the implementation of the programme.

The draft situation analysis, together with a draft programme document for an integrated management of the river, was presented at the National Roundtable for developing a "Programme for Sustainable Consumption and Production in Akaki River Basin" that was held on the 6th and 7th of June 2005 in Addis Ababa. Based on the inputs from this consultative forum[2] the Situation Analysis report has been finalized for submission to the stakeholders and main partner institutions.

[2] The feedback from the Consultative Forum of June 6th and 7th is summarized in Appendix 1.

2. POLLUTION STATUS AND THE VAROUS IMPACTS ON THE AKAKI RIVER

2.1. MAJOR CONTRIBUTORS TO THE POLLUTION OF THE AKAKI RIVER

2.1.1. MUNICIPAL SOLID WASTE

Better employment opportunities in Addis Ababa and its surroundings attract a large number of workers and their families to settle in the vicinity. In the past two decade alone the population of Addis Ababa has doubled, from 1.3million in 1984 to about 2.6million in 2004. The dramatic increase in the population of the city has brought about issues of solid waste management. Municipal solid waste[3] is ranked as the major environmental issue in Addis Ababa (EnDA Ethiopia and Preceup, 1999; Campbell et al, 2004). This is understandable since there are inadequate disposal facilities thus leading to the dumping of household waste in the vicinity of the rivers (Gebre Emmanuel, 1993). Projection of a survey by the Health Bureau of Addis Ababa shows that over the fourteen years (1989-2002) there has been a continuous increment in the daily waste generated (Tamiru et al 2004).

The daily volume of solid waste generated in the city of Addis Ababa is estimated to be about 1,335 cubic meters (468 tons). Taking the population to be 2.5 million, the unit waste generated is predicted at 0.45 lit/capita/day (0.15 kg/capita/day). Based on the available data the source for the solid waste has been identified to be domestic (76%), commercial (9%), street sweepings (6%), industrial (5%), hotels (3%), and hospitals (1%). The waste has the following general composition namely organic matter (kitchen waste) 8%; recyclable fraction (leather, glass, plastic, metals, textiles, paper, rubber, wood) 10%; combustible fraction (grass, leaves) 20%, non-combustible 3%, ashes 28% and fines 30% all by weight (NOR Consultants 1982).

[3] In this section the type of solid waste discussed includes those generated from commercial centers, domestic households and local institutions. The solid waste generated from industry and other such sources is discussed under the respective sources.

It is estimated that only 54% of the solid waste in Addis Ababa is collected and disposed of properly. The remaining waste builds up within the inhabited areas, open spaces and along streams running through the city since the collection and transportation service is irregular and inefficient (Adane 1999; JICA 1999; de Stoop 1998). Intermediate dumping containers (metallic containers) are also not evenly distributed in the city (Tamiru et al, 2004).

The high amount of solid waste generated combined with the inefficient means of collection and transportation has become an important source of pollution of the rivers since leachates transported by runoff during the rainy season end up in the surface water bodies of the region (Adane, 1999). Leachates also percolate to the groundwater system based on the geology of the region (Tamiru et al 2004). Furthermore, as solid waste is not segregated into appropriate fractions during disposal (i.e. organic, chemical and other categories) there is a possibility for toxic compounds from household and other sources to enter the rivers. The situation becomes formidable in market areas like the Mercato, where a high amount of waste is generated. The situation is also critical in smaller towns like the Akaki, where waste collection is only intermittent (Campbell et al, 2004).

The main landfill site for the city of Addis Ababa (Koshe) is situated at Repi (Figure 2). Although details of its construction are not available, it seems unlikely that it has a protection system at the base (Birhanu 2002). Furthermore waste is spread over a wide area (0.3 km^2). Estimates by the Health Bureau of Addis Ababa, show that the already disposed refuse at this site is about 6 million cubic meters. A combination of factors including the topography of the area, extensive fractures in the rocks and the thin soil cover has therefore permitted leachates from this site to percolate into the groundwater system (Tamiru et al, 2004). In particular in the rainy season, when there is a high amount of rainfall and consequent rise in groundwater level, the leachate level becomes high in the groundwater system. Apart from this, leachates from the site have also been observed to enter nearby streams, which ultimately enter the Little Akaki (Birhanu 2002).

Cognizant of the need to establish new solid waste disposal sites, the Addis Ababa city Administration has identified four sites for such purposes. These sites are situated at Filli Dono (west of the Mercato), Yeka Abado (northeast of Megenagna), Yeka Bode (southeast of the Kotebe sewage treatment plant) and at Dertu (west of the Kaliti sewage treatment plant). Geographically these sites are ideal in that they are all situated in the peripheries of the city (Figure 2). However several important factors, including geological aspects, should be given due consideration in the establishment of such waste disposal sites (Personal Communication, Dr. Tamiru Alemayehu, AAU). The lack of a comprehensive Environmental Impacts Assessment study can bring about the same problems that are being encountered at the Koshe landfill site. In due course of time the expanding city will also encompass these new solid waste disposal sites, which at the present appear to be very peripherally situated.

2.1.2. DOMESTIC SEWAGE

The liquid refuse in the city of Addis Ababa is generated from different sources. These sources include toilets, petrol stations, garages, industries, etc. Although all these sources result in substantial pollution, this section gives particular focus to domestic sewage. Discharges from the other sources will be discussed in the appropriate sections.

Currently, sewage collection in the city of Addis is partially based on toilet pits and partially on a centralized system. However, as the sewage removal is incomplete there are obvious signs of pollution of surface waters. The data on housing shows that a total of 380,300 housing units are found in the city. Out of this the sewerage system covers 20,000 households, only 6000 being functional due to financial constraints (Enda Ethiopia and Preceup 1999).

An estimated 100,000m^3 of domestic wastewater is being produced in Addis Ababa per day (Benoist, 2002). Hydrological investigations show that from the total amount of water supplied to the city, 70% returns as sewage with high organic pollution. Approximately 60% of this sewage flows directly into the two Akaki Rivers (Adane, 1999). Although data is not available, the situation is

expected to be severe for the rural population outside the towns of Addis Ababa and Akaki, where sewerage facilities are very limited.

In Addis Ababa 74 percent of the households have toilet facilities. However as a result of the financial burdens and the topography of the region, only 12 percent of the inhabitants are provided by a centralized sewerage system. Based on the Waste Water Master Plan Study, this figure is estimated to increase to 16 percent (456,000 inhabitants) and 22 percent (848,000 inhabitants) by the year 2005 and 2015, respectively. Currently the remainder (about 60 percent of the households) is served by sanitary facilities connected either to septic tanks, aqua privies or dry pit latrines. Overflow from septic tanks is a major problem, as the sewage collection and transportation service is intermittent in the city. Apart from this, drainage systems designed for other purposes are used as sewer lines to collect and transport sewage (Tamiru et al 2004).

The main sewage treatment plant in the city of Addis Ababa, is located in Kaliti, northeast of the Akaki water well field (Figure 2). A similar treatment plant is also functional in the eastern side of the city at Kotebe. The Kaliti treatment plant is situated in the industrial area of Addis and covers around 40 hectares of land. The plant slopes to the little Akaki River. The treatment undertaken here essentially involves circulation of sewage in various ponds for a total of about 30 days, during which the level of BOD falls below 5mg/l. Regarding its capacity, the plant was designed to serve a population of 50,000 inhabitants treating up to 7,600m^3 of sludge per day. However currently it receives only 4,600m^3/day from sewer lines and waste disposal trucks. This suggests that the plant still has the capacity to handle more sludge if the collection and transportation capacity improves. Apart from the underutilization of its services, the processed sludge also remains unused despite its potential positive contribution to agriculture (Campbell et al, 2004).

2.1.3. INDUSTRIAL WASTE

Industrial waste is an important contributor to the pollution of a number of rivers in Ethiopia. Pollution from poorly located and managed industries is especially a

problem in the urban centers of the Awash River Basin where land use zoning has come too late, relocation is too costly, and new production methods are not affordable. Most of the medium and large scale industries in Ethiopia (more than 65%) are located in Addis Ababa and the nearby town of Akaki (CSA 1999). Incorporating small scale establishments the number of industries in the city is estimated at 1100 firms (Tamiru et al, 2004).

A majority of the industries in and around Addis Ababa discharge their untreated waste directly into the Akaki Rivers. The volume of liquid waste generated from individual industrial firms varies from 1-1000 m^3/day (Benoist, 2002). Industries in the region also account for about 9% of the total waste generated in the city. The predominant industries in Addis Ababa and the surroundings can be categorized into the following namely; food and beverages, leather and footwear, wood, paper and printing, textiles, tobacco, chemicals, non-metals and metals (CSA 1998).

Box 1: Number of Industrial Establishments in Ethiopia (1998/99-1999/00)

Type of Industry	1998/99	1999/00
Food and Beverages	228	235
Tobacco	1	1
Textile	36	36
Clothing	28	25
Leather and Leather Products	49	53
Wood Works	16	16
Paper Products and Printing	60	64
Chemical and Chemical Products	43	40
Rubber and Plastic Products	32	29
Non Metallic Mineral Products	88	85
Metal and Metal Products	46	59
Machinery and Equipment	20	15
Motor Vehicles	11	11
Furniture	121	119
Total	**779***	**788***

* Figures exclude small scale establishments

Source: Central Statistics Authority, 2002

A report by the World Bank (2002) shows that, in the Awash River Basin the main emitter industries are food and beverage (contributing 59% of all organic water pollution), textiles (21 percent) and pulp and paper (11 percent). In Addis Ababa and the surroundings metal and leather/tanning industries also become important contributors. The pollution load from selected industries in Addis Ababa and the surrounding is found in Appendix 2a. So far the health statistics associated with these pollutants are not available (Campbell et al, 2004). However a review of the compounds used by these industries reveals that a variety of chronic and acute toxic effects are to be expected in human and other species (Appendix 2b).

By 1990 only 6% of the industries in the city of Addis Ababa and the surroundings had treatment plants. This figure did not rise significantly by 2000, i.e. 20% had treatment plants (Desta 1990; 2000). In fact the figure may be an overestimation as it did not assess the proper functioning and utilization of the treatment plants available in these industries (Personal Communication, Dr. Desta Mebratu, UNEP). A similar survey by Zeraikob and Girmay (1999) estimates that in 1999, only 4% of the industries in Addis Ababa had functional treatment plants.

The unabated industrial discharge has contributed to the pollution of the two Akaki rivers and their tributaries resulting in elevated levels of a variety of pollutants in different environmental matrices including vegetables (Fisseha, 2002), soil (Fisseha, 1998), stream sediment (Teklehaimanot, 2003), surface water (many studies), groundwater (Tamiru, 2001) and aquatic biota (Teklehaimanot, 2003). The problem associated to industrial pollution can mainly be attributed to capacity issues related to the implementation of a system for a routine follow-up of industries. The mainstreaming of environmental impact assessment, the development of a comprehensive water quality standards and raising the awareness of different members of the society are also areas that require attention to alleviate the problem (refer to Section 3).

2.1.4. WASTE FROM OTHER SOURCES

Agriculture

In the peripheral parts of Addis Ababa, crop production and animal husbandry is carried out extensively on an individual or cooperative basis. In the urban centers of Addis Ababa animal husbandry is a predominant economic activity. The cattle population in the city is estimated at 133,100 (Tamiru et al 2004). These cattle are either reared in the compounds of the individual owner or in the open spaces and along the river banks. Although figures are not available, it is to be expected that a substantial amount of organic waste is generated from cattle rearing. In the rural areas the predominant agricultural activity is crop production using small plots of land.

One of the major pollutants with regard to agriculture is associated to erosion of the soil in the upper catchments of the river. This is especially intense in the rainy season when there is high surface runoff. As a result of soil erosion chemical fertilizers added to increase productivity also enter the streams. This in turn contributes to the eutrophication of the streams in and around Addis Ababa. One of the main components of chemical fertilizer in Ethiopia, i.e. urea, is a major polluter of groundwater systems. This is mainly a result of the associated nitrate which is mobile in subsurface flow system (Tamiru et al 2004). Solomon (2000) for instance, shows that the shallow groundwater around Laga Dadi has an elevated nitrate level (2.7mg/lit), possibly a result of the extensive use of fertilizers in the surrounding farmlands.

Currently the upper catchments, especially around Yeka and the surrounding are highly affected by erosion. This has thus forced the Addis Ababa Environmental Protection Authority (AAEPA) to undertake an extensive rehabilitation of this sub-catchment (refer to Section 4).

Petrol Stations

Petrol Stations in Addis Ababa are built at random. It is therefore a common phenomenon to see filling stations close to resources that get contaminated

easily. By the year 1999 there were sixty three filling stations in the city (Tamiru et al 2004). This figure is expected to increase steadily in recent years as new service providers, such as the National Oil Corporation (NOC), are coming into the picture aiming to start up a number of filling stations. The main petroleum depots including the ones for Mobil, Shell and Total are all situated in the southern part of the city, in close proximity to the main industrial region at Kaliti (Figure 2).

According to Tamiru et al (2004) the possible major threat from petrol stations comes from the subsurface metal storage tanks, which through rusting and other processes start leaking oil to the subsurface water resources. The lack of regular inspection of these storage tanks is one of the reasons presented by the research team (Tamiru et al) as a problematic area. Apart from this, through associated services like the washing and greasing of cars, oil, washing solvents and other associated contaminants enter surface water bodies. This in particular may be a major source of pollution since the high-jet pressure water, used during the cleaning process, generates a high amount of liquid waste which ultimately joins the surface water body in the proximity. Currently there is no data available as to the contribution of the filling stations in the city to the pollution of the water bodies in the vicinity.

Health Facilities

Health facilities are among the important sources for the waste generated in the city of Addis Ababa. Among the types of wastes generated by such sources are pathogenic substances and hazardous wastes that include chemicals, solvents, disposable syringes and needles. According to NOR Consultants, in 1982 one percent of the solid waste generated was from hospitals. Although this figure has not been updated, it would be sensible to expect that the contribution from health facilities will have increased steadily. This especially holds when considering that the number of health facilities has increased dramatically in the last two decades.

Most health facilities have incinerators to dispose of the toxic and pathogenic waste they generate. However, some health facilities have also been observed to

utilize the garbage containers that provide services to all residents (Tamiru et al, 2004). It is to be noted that Healthcare Waste Management Legislation has been enacted in Ethiopia (WHO 2003). Although obligatory to have incinerators and other specialized waste disposal facilities in such health delivery centers, the limited follow-up and lack of proper mechanism for enforcement is a serious concern.

Garages

In the city of Addis Ababa there are more than 400 garages, excluding those built for non profit purposes in governmental and non governmental organizations (Tamiru et al 2004). The waste generated from these sources is untreated. As a consequence a number of ecological and human health implications are to be expected. For instance damages to plants were observed in streams having a high level of used black oil (Tamiru et al 2004). Currently there is no data available as to the contribution of garages in the city to the pollution of the water bodies in the vicinity.

Apart from the above mentioned sectors, hotels and laundries are also possible sources that generate various contaminants that pollute the rivers in and around Addis Ababa. The number of possible polluting sources of the rivers in and around Addis Ababa is presented below.

Box 2: Different polluting sources in Addis Ababa and the surroundings.

Possible Source for Pollution	Number of potential sources in Addis Ababa	Year for census
Household	380307	1994
Industry	1078	1998
Garage	401	1998
Health Center	327	1998
Petrol Station	63	1998

Source: Tamiru et al 2004.

From the above table in (Box 2) it can be deduced that when considering potential polluting sources domestic households become the most important. However this comparison does not take into account the nature of pollutant discharged from the different sources[4] and the availability of the discharges in the stream network of the city. It is thus extremely important to make a detailed study to quantify the contribution of the different sources to the pollution of the streams in and around Addis Ababa.

2.2. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

2.2.1. HUMAN HEALTH AND ECOLOGICAL IMPACTS

As stated in the previous section, the rivers in Addis Ababa and the vicinity are extremely polluted as a result of receiving uncontrolled domestic and industrial waste disposal. The low oxygen level and the high level of metals and other toxic compounds in both the Great and Little Akaki rivers are manifestations of this situation. In fact, these rivers do not contain higher aquatic species, such as fish. The only species to be found are worms *(i.e.Tubifex tubifex)* that can survive under low oxygen conditions (Teklehaimanot, 2003).

When considering human health environmental factors such as the lack and access to safe water and sanitation, indoor air pollution and exposure to agrochemicals account for nearly 30 percent of the total burden of diseases in Ethiopia. As far as access to safe water and sanitation, Ethiopia ranks among the lowest by international comparison. Shortcoming in this area is especially manifested by the high under-five mortality and diarrhea prevalence (Campbell et al, 2004).

[4] In general toxic and hazardous waste is potent than oxygen demanding waste (i.e. sewage) that predominantly results form households. Thus to have an accurate assessment of the contribution of the different sources it is important to determine the types of pollutants discharged from these sources and the quantity. In the development of environmental and human health standards for instance, the effects of the different pollutants are taken into account (refer to Appendix 10, i.e. the ambient Environmental Quality Standards of the Federal EPA).

Regarding the pollution of the Akaki River, impacts on human health becomes very serious in downstream locations in the Eastern Shoa Zone of the Oromia region, where there is limited alternative source for drinking water. Studies conducted by the Oromia Environmental Protection Office (OEPO) in the Alemgena, Gimbichu and Adaa Liban districts show that water related diseases are rampant in the region. Diarrhoea, cough, skin rashes, typhoid, amoebic dysentery, giardia, prenatal death, maternal mortality and impact on intellectual capacity were all assessed to be high in the region. The problems most probably are results of the different pollutants present at high concentration in the drinking water available (OEPO 2004).

In fact in these districts out of a population of 25,761 surveyed, 18,563 (72% of the population) was at risk (health related and/or economic) as a result of the pollution of the Akaki Rivers. The situation is especially a threat to a population of about 9,500 (37% of the population surveyed) that live along the river course and literally depend on the river water for domestic, livestock and drinking purposes (OEPO, 2004).

In the rainy season in particular, health related complaints exponentially increase in the region (OEPO 2004). This is most probably a result of surface runoff, which washes all the waste from the city into the rivers due to the mountainous topography of the region. Hence, although present throughout the year, health problems increase in the region in the rainy season when there is a higher pollutant load and surface runoff to carry these substances for a longer distance.

The city of Addis Ababa is also not immune to the public health problems mentioned above. Endemic diarrhea, dysentery, intestinal parasites, skin infection and eye inflammations also predominate in the region (Bojo and Segnestam 2002). Based on data from the Ministry of Health (1981), the rate of infant mortality in Addis Ababa in 1981 was 107/1000 live births while the crude death rate was 37/1000 people (Birhanu, 2002). In 2003/4, these rates were still high at 61/1000 and 35/1000, respectively (MoH, 2004). These high rates are mainly a result of communicable and environmental diseases that result from

poor sanitation and generally poor living conditions. Diarrhoea in particular was found to be the leading cause of morbidity, accounting for 16.5% of all cases recorded.

The use of the highly polluted irrigational surface waters for irrigation of horticultural crops will also have chronic health implications (Fisseha, 2002; Birhanu, 2002). Consequential high build up of metals i.e. arsenic in Swiss chard (*Beta Vulgaris* var C*irca* L.) and chromium in lettuce (*Lactuca Sativa* L.) has already been reported from a number of farms using the Akaki River for irrigation. This suggests possible human health risks via food consumption. In the same study the observed level of iron and lead were also high enough to raise serious concern (Fisseha, 2002).

On a similar note, in certain parts of the city of Addis Ababa, shallow springs are used for religious purposes (i.e. holy water). One example is the Lideta spring whose feeder, i.e. the Lideta River, is a tributary of the Little Akaki and known to be extremely polluted as a result of waste from the Mercato area.

The level of various pollutants in the streams in and around Addis Ababa is presented in Appendix 3 together with the recommended standards for these pollutants in drinking water and the ecosystem.

Box 3: Source for drinking water for urban and rural population in Ethiopia (CSA, 2000)

	Urban	Rural	Total
Piped to dwelling	0.6	0	0.1
Piped to compound	28.2	0	4.6
Piped outside compound	52.0	5.3	12.9
Open well	1.7	3.6	3.3
Open spring	5.1	47.2	40.4
Covered well	2.1	3.0	2.8
Covered spring	3.2	5.2	4.9
River	**6.9***	**31.4***	27.4
Ponds/Lake/dam	**0.1***	**4.3***	3.6
Other	0.1	0	0.1

* Over 7 percent of the urban population and greater than 35% percent of the rural population uses rivers, ponds, lake and dams for drinking purposes.

2.2.2. SOCIO-ECONOMIC IMPACTS

The economic and social costs of pollution are important aspects to consider in such an analysis. Currently environmental economics is a discipline that is gaining momentum world-wide because it brings together economic and environmental information into a common framework where the positive and negative contributions of development projects to the environment and vice versa can be clearly assessed. For instance, a study that compares the health cost incurred as a result of air pollution versus the profit made by air polluting industries brings environmental and economic issues on a common platform for decision makers. Such an approach has thus become popular in giving a socio-economic dimension to environmental studies.

There are only a few studies that focus on the socio-economic aspects of the pollution of the Akaki Rivers. However several studies have been conducted on urban poverty and its impacts in the Addis Ababa area. Most of these studies show that the most predominant health complications in the area are related to the lack of clean water. Although estimates are not available, in Ethiopia (where health services are subsidized) the consequent cost incurred on the government due to easily preventable water related diseases is expected to be tremendous.

Similarly, a survey of the downstream population shows that people utilizing the Akaki River for drinking purposes spend about 610 Birr/yr per household on health care, mainly for the control of water related diseases (OEPO, 2004). This is a significant amount in comparison to of the average yearly income of 950-1000 Birr/person in Ethiopia. Additional high financial losses also result from death and general poor health of the cattle and low milk production. Furthermore, as a result of the widespread health complications in the human and cattle population, it has become a requirement to hire farm labour and cattle, at a cost of 10birr/day and 700-800birr/ox/yr, respectively.

In the broader context environmental economics is beyond the direct comparison/assessment of the economic and environmental aspects. In fact the

current interest in environmental economics arises from the discrepancies in economic indicators such as Gross Domestic Products (GDP), which do not account for assets such as natural capital, i.e. forests, water, etc. So far, the benefits of such capital assets were rarely considered in the economic appraisal of projects. For instance, the economic opportunity lost as a result of the loss of biodiversity or fishery in the rivers of Addis Ababa due to the proliferation of polluting industries has not yet been accounted for. Nevertheless accounting for the natural resources capital would help integrate environmental concerns into the decision making process.

2.3. SUMMARY

The previous sections illustrate that both Akaki Rivers are highly polluted. However, the comparison of levels from a number of studies shows that the Little Akaki is more polluted than the Great Akaki River (Appendix 3). This is possibly due to a higher number of industries that discharge their waste directly into this river and its tributaries. Discharges from densely populated areas like the Mercato also join the streams, which ultimately end up in the Little Akaki (Figure 2). As a consequence, the Little Akaki has a characteristic greenish-dark colour with a pitch-dark sediment layer and a peculiar pungent odour, especially in the dry season. This is a product of the high industrial and domestic waste generated in the vicinity. Litter of plastic bags and household waste along the banks is also a common sight. The groundwater in the area, in particular the shallow groundwater that is fed by the Little Akaki River also contains a high pollutant load (Tamiru, 2000). In Appendix 3 the current environmental status of the river is elaborated based on the outcome of a number of water quality studies conducted in the region.

The increase in pollution in the Akaki Rivers has been addressed by most environment related studies in the country. However, most of the studies (recent or past) have based their research on a few selected parameters as indicators due to lack of facilities to conduct a broader battery of tests locally and the expensive costs to do them abroad (Appendix 8). Furthermore, in a majority of

the cases the levels are measured only through the study of surface and/or groundwater. However, the level of pollution can better be assessed if as many different types of pollutants are measured in a variety of environmental matrices including sediment, water and suspended particles. Routine and seasonal measurements will also complement this effort by enabling to develop a pollution trend that will help evaluate the successes and drawbacks of intervention measures.

In a situation where a variety of pollutants are discharged into a river system, a combination of individual toxins might yield synergetic effects whereby resultant toxic effects are much higher than the effects of the individual toxins (Hamers, 2000). Synergistic effects have been demonstrated in several studies. For instance, in studies conducted by various researchers (Biesinger et. al., 1986; Spehar and Fiandt, 1986; and Enserink et. al., 1991) a mixture of metals resulted in toxicity in aquatic species at levels that the individual metal did not cause toxicity. It is thus important to note that in a worst-case scenario we may be underestimating the synergistic effects of these toxins in our measurements of individual pollutants.

Currently the importance of cleaner cities is recognized, among others by the Addis Ababa City Administration, especially due to its implication for future investment. Innovative approaches to urban waste such as composting are undertaken by private sector enterprises that are seeking organic input for urban gardening (Personal Communication, Eden Melke, Dynamic Sanitary Services). The practice is especially well developed along streams in the Western part of Addis Ababa, a densely populated area where there are a high number of activities polluting the Little Akaki. The intensive vegetable farming in these areas (i.e. western part of the city) could reduce costs of both waste disposal and farm input supplies. The use of reed-bed technology in engineered wetlands could also make a major contribution to the control of industrial pollution at a relatively low cost (Campbell et al, 2004).

3. POLICY AND INSTITUTIONAL FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT IN ETHIOPIA

In general, environmental aspects are typically treated as non-issues in planning and decision-making. Rationalized with arguments like: “poverty reduction and economic growth first”, environmental management is marginalized on the real political agenda. Furthermore, so far the task to attain environmentally sustainable development has mainly been the responsibility of environmentalists, not incorporating economists and other expertise in the developmental fields of demography, health, social services, etc. This in turn has resulted in the generation of insufficient data for formulating pragmatic, comprehensive and efficient policies. In the past, Ethiopia did not have any formal and comprehensive environmental management framework. For the first-time a National Environmental Policy was formulated and approved in 1997 (Appendix 4).

3.1. POLICY AND LEGISLATIVE FRAMEWORK

In the water sector, administrative legislation was first used in Ethiopia in the 1940s. This legislation mainly focused on environmental health issues such as the protection of water supplies. This legislation was not as such important in the context of water resources management as it dealt merely with the control of urban sanitation. The first legislation on water pollution was passed in 1981 (Proclamation 217/1981). This was followed in 1994 by a legislation to regulate the use of water resources (Proclamation No. 92/1994).

In March 2000 the Ethiopian Water Resources Management Proclamation (No. 197/2000), superseded Proclamation 92/1994. In July 2000 the Ministry of Water Resources (MoWR) also developed an important policy document for the Management of Water Resources in Ethiopia. This document incorporates policies on several cross cutting issues, such as those dealing with groundwater resources, watershed management and water-rights allocation. Currently the Ethiopian Water Resources Management Regulation (Regulation No. 115/2005)

of MoWR is a comprehensive regulation developed to regulate several aspects of the utilization of water resources.

Box 4: The Ethiopian Water Resources Management Regulations- In the area of water resources, the dominant trend of the 1970s and 1980s has been the construction of infrastructures (development of water projects). During the early 1990s, the focus shifted to the management of water resources but it was still largely based on sectoral lines. Integrated water resources management, with a broader multi-sectoral approach in the consideration of social and environmental issues, became the main trend by the end of the 1990s. Stakeholder participation also became an important aspect of water planning and management. This came about from understanding the need to address issues such as demand management, efficient and equitable allocation of water (among uses and between users), environmental and social impacts and other such aspects.

The current Water Resources Management Regulation of the MoWR takes into account most important aspects in the allocation of water resources for various purposes. A permit system is also designed to monitor (along with other factors) the use of water, construction and maintenance of infrastructure for water utilization, discharge of waste water and the competency of service providers in the water sector.

Although such a regulation is of utmost importance for the country, some aspects of the current regulation overlap with already covered areas of the Environmental Protection institutions in the country (Federal and Addis Ababa EPA). One such aspect is industrial pollution control. Currently, the EPA has developed a comprehensive standard for pollutants resulting from the different industrial sectors (Appendix 10).

Following its formation in 1995, the Environmental Protection Authority (EPA) has issued two important proclamations relevant for the management of water resources namely: the Environmental Pollution Control and the Environmental Impact Assessment Legislations, both enacted in 2002. Currently, the EPA has also developed a comprehensive standard for pollutants resulting from the different types of industries (Appendix 10). This document together with an Industrial Pollution Prevention and Control Regulation has been submitted to the Council of Ministers for approval.

Box 5: The Environmental Impact Assessment (EIA) Legislation- Environmental Impact Assessment (EIA) has been evolving as a tool for integrating environment and development management worldwide. However, it is only in recent years that it has become a requirement for developmental activities in developing countries, including Ethiopia. EIA is a process that helps assess the impacts of a planned activity on the environment providing decision makers with an indication of the likely consequences of the development actions (FSS, 2004).

Although the legal framework has been set up, EIA in Ethiopia has not gone significantly beyond its application in internationally funded projects and programmes. The procedures for commissioning, conducting and reviewing EIAs are also not clearly established (WAAS International PLC, 2003).

Box 6: The Pollution Control Proclamation- Complementary to the EIA legislation, which requires developmental activities to give considerations to environmental impacts before their establishment, the Pollution Control Proclamation requires ongoing activities to implement measures that would reduce their degree of pollution to a set limit or quality standard. One of the dictates of the legislation is thus to ensure through inspection the compliance of ongoing activities with the standards and regulations of the country i.e. environmental audit. Environmental audit is important in that it enables the government to determine whether an ongoing activity is in compliance with government regulations, guidelines and codes and permit conditions. In addition it also helps the proponent identify areas where operations can be improved to minimize the negative impacts on the environment and how this can be achieved at a relatively cheaper cost**.** Unfortunately, environmental legislation promulgated by the EPA and other regulatory agencies has not been extensively implemented, leaving many loopholes for polluters (Kumie and Kloos, in press).

Box 7: Industrial Pollution Prevention and Control Regulations- This regulation is developed to ensure the compatibility industrial development with environmental conservation. To assist the implementation of this regulation, comprehensive standards have also been developed to prevent industrial pollution. The standards are therefore to be used as indicators of pollution limits (beyond which pollutant levels would not be tolerated). The development of these documents is also part of the implementation of the policy and the environmental pollution abatement strategy contained in the Environmental Policy of Ethiopia (1997).

The document is to be applied and modified as per the available scientific knowledge on the different pollutants emitted. Regional states can also utilize the guideline as a platform to develop more stringent standards taking into consideration particular ecological conditions in their localities provided that these present standards are used as the minimum. Currently, the documents have been submitted to the Council of Ministers for approval.

The Ministry of Health, the Quality and Standards Authority and other governmental bodies with mandates to control pollution and regulate water quality have also been instrumental in the enactment of such regulations and legislations. In Appendix 4 policies, legislations and regulations with relevance to pollution and water quality issues are listed.

3.2. INSTITUTIONAL SET-UP AND RESPONSIBILITIES

Currently, the Ethiopian Federation comprises nine regional states. In addition, there are two urban administrative centres (Addis Ababa and Dire Dawa) under the central Federal Government. The regional states are organized in such a way that major decisions are made at the Woreda level (basic administrative unit). At the Federal level the Environmental Protection Authority has been established with the objective of ensuring sustainable utilization of the country's natural resources. However, as in many other countries, a number of government institutions have responsibilities or concerns for environmental matters. This includes various agencies that are part of the six major coordinating or umbrella ministries and also several smaller ministries that report directly to the Deputy Prime Minister (Appendix 5).

Involvement in environmental matters varies greatly among sectoral agencies. Examples include environmental education in the Ministry of Education, public health issues in the Ministry of Health, and catchment management in the Ministry of Water Resource. These agencies have their own legal responsibilities and have developed their own policies to address common environmental issues. Sometimes their responsibilities overlap as the different agencies have interests in the same aspects of the environment, but from differing perspectives. For instance, water issues are of concern for power development, irrigation and urban water supply. This overlap of interests also occurs at the regional level and within urban areas.

Below is a summary of the responsibilities of the main environment related governmental institutions with regards to environmental management:

- **Environmental Protection Council:** is established as a cross-sectoral coordinating body that advises the Environmental Protection Authority and supervises its activities. Its mandate includes
    - Reviewing environmental polices, strategies, and laws proposed by the EPA and issuing recommendations to the government;
    - Providing appropriate advice on the implementation of the Environmental Policy of Ethiopia; and
    - Reviewing and approving directives, guidelines, and environmental standards prepared by the EPA.

- **Ministry of Finance and Economic Development (MoFED):** has the responsibility to coordinate planning, programming and consolidation of the overall investment programme in accordance with the Federal Policy on the Environment.

- **Federal Environmental Protection Authority (EPA):** has the responsibility to regulate ("police") environmental compliance and develop policies for the sustainable utilization of natural resources. The institution is also responsible for providing support functions in different aspects of natural resources management. This involves ensuring that environmental standards are enforced and that the mainstreaming of environmental concerns in sectoral activities is facilitated.

- **Ministry of Water Resources (MoWR):** In accordance to one of its mandates, determines the conditions for the optimum allocation and utilization of water resources. Individual programmes and projects on water resources are monitored by the appropriate federal and/or regional implementing and/or mandated agencies. MoWR is also responsible for undertaking measures to prevent and control the pollution of water resources.

- **Ministry of Health (MoH):** As per the old Public Health Proclamation of 1942 and as amended in 1947 (Appendix 4), the Ministry of Health has the mandate to organize comprehensive public health services required to implement measures of sanitation to prevent and control the occurrence of diseases in the area of foodstuffs and beverages, buildings and factories including the supervision of water supply, well drilling, drainage, garbage and sewerage construction systems.

A comprehensive listing of the mandated agencies and their responsibilities is found in Appendix 5.

3.3. CAPACITIES AND GAPS FOR ENVIRONMENTAL MONITORING AND ANALYSIS OF THE AKAKI RIVERS

Existing reviews (Tedla and Lemma, 1998; Desalegn, 1999; FSS, 2004 and MoWR, 2002) indicate the lack of coordinated efforts as one of the major drawbacks in the development and management of water resources in Ethiopia. Moreover, the following aspects are identified as problematic areas in water resources development and management. These include:

- Low participation of the public
- The lack of an integrated management information system (MIS)
- Legislative aspects
    - Sectoral nature of legislations;
    - Gaps in existing environmental legislation; and
    - Lack of water quality standards.
- Institutional shortcomings
    - Management issues;
    - Lack of coordination;
    - Institutional instability; and
    - Overlap in mandates.
- Capacity and financial limitations

The identified problem areas and the consequences are described in detail in Appendix 6.

When considering the Akaki River the main issue of concern is the deterioration of its water quality. Hence, as a prerequisite for implementing mitigation measures the routine follow-up and monitoring of the water quality of the river is of utmost importance. Such regular follow-up is also required for the sources that discharge into it. In relation to this, institutional capacity in laboratory facilities and technical manpower are areas that need focus. Together with supportive legislation for protecting water quality, capacity building in these aspects will ultimately bring about improvement of the water quality of the Akaki. To assess capacities and gaps a survey of the major environment, health, research and water sector institutions in Ethiopia was carried out in this study. This was carried out through interviews based on a questionnaire that was developed by the consultant (Appendix 7). In all cases the interviews were made with high placed and responsible officials of each institution. The outcome is summarized below.

- ***Federal Environmental Protection Authority*** is the main institution for environmental protection in Ethiopia. The Authority has a laboratory facility with the capacity to measure a variety of pollutants including trace metals, organic pollutants and toxins from industrial sources. The Authority also works closely with the Addis Ababa Environmental Protection Authority in the analysis of samples. A technical team in the Pollution Control Department undertakes regular monitoring of the water quality of the rivers in the Awash Basin. The output of this survey will be a seasonal report on the water quality of the surface water bodies in the Awash River Basin.

- ***Addis Ababa Environmental Protection Authority*** is one of the main institutions that is responsible for monitoring the water quality of the Akaki Rivers. In 2004/2005 the Authority has spent over 4 million Ethiopian Birr (greater than half a million US dollars) to upgrade its laboratory facilities. A Memorandum of Understanding signed with the Federal EPA has also established the basis for utilizing the facilities of the two Authorities in a complimentary manner (Personal Communication, Head of the Pollution Control Department). A technical team in the Environmental Management and Control Department undertakes regular monitoring of the water quality

of the Akaki Rivers. This team is also responsible for enforcing the environmental compliance of industries in and around Addis Ababa. However following a *'supporting before penalizing'* principle, the Authority together with other interested institutions, gives the required assistance for industries to help them attain the required level of compliance.

- ***Oromia Environmental Protection Office (OEPO)*** is also an institution that has the responsibility of monitoring the water quality of the Akaki Rivers. Although active in issues of the Akaki River, currently the institution does not have a laboratory facility for analysing water samples. Recently a technical team in the Environmental Pollution Study and Control unit has undertaken an epidemiological and socio-economic impact survey on the pollution of the Akaki Rivers. However there is a great need to build up the capacity of this team (Personal Communication, Head of OEPO).

- ***Ministry of Water Resources (MoWR)*** has developed integrated water resources management master plans for almost all major river basins in Ethiopia. At the Ministry, water quality analysis is performed through the laboratory facilities of the Water Works Design and Supervision Enterprise (WWDSE). In the next three years the ministry also plans to set up its own laboratory facility. Currently the laboratory of WWDSE has the facility to measure a number of pollutants, mainly trace elements and eutrophication indicators. Kits are also available for rapid/efficient in situ measurement of samples. Under the MoWR there are two technical teams, i.e. the Water Resources Quality Control and the Permit and License Execution teams which undertake surface and groundwater quality monitoring. The Permit and License Execution Team has the responsibility to implement the water use oriented permit system the Ministry has currently introduced. Both teams require capacity building and technical assistance to undertake their tasks efficiently (Personal Communication, Head of Water Resources Administration and Urban Water Supply and Sanitation Department).

- ***Ministry of Health (MoH)-*** As a primary health sector institution the MoH has been actively involved in water quality (drinking) and solid waste management issues of the country. The Ministry makes use of the laboratory facilities available at the Ethiopian Health and Nutrition Research Institute (EHNRI) and the Quality and Standards Authority of Ethiopia to determine the quality of drinking water. In-situ measurement kits are also available for use in the surveys the Ministry undertakes. A working team *'Water Quality and Waste Management Control Team'* is currently active in assessing the quality of drinking water at the national level. Thus, the Ministry, in collaboration with the respective regional health bureaus, undertakes routine sanitation surveys to monitor the waste that is generated from a number of sources including hospitals, hotels and research facilities is properly disposed.

- ***Addis Ababa University (AAU)-*** The Faculties of Science, Engineering and Medicine have laboratories that could be utilized for monitoring and analysing water. The Faculty of Science in particular has a highly specialized laboratory that can be used to measure various categories of pollutants in water. There is also tremendous technical expertise in the area. Currently the available facilities at the faculty are being organized in such a way that they can be utilized by various local and international organizations requiring the services (Personal communication, Dean of the Faculty of Natural Sciences). Plans have also been developed to give technical training in laboratory skills to various partner institutions with the intention of building capacity in the area. The Addis Ababa Environmental Protection Authority is going to be one of the beneficiaries of this scheme. Various researches on the water quality issues of the Awash River Basin have also been undertaken by researchers at the university. However, as an academic institution with its own programmes, the AAU does not regularly monitor the water quality of the Akaki Rivers.

- ***Oromia Water Resources Bureau*** is actively involved in providing potable water supply for the population in the Oromia Region. Among the

dominant water quality issues in the Region is the problem associated to high level fluoride in the groundwater resources of the Region. To overcome the fluoride problem the Bureau is currently utilizing the surface waters of the Awash River as an alternative source for drinking purposes. The town of Adama for instance currently switched its water supply from groundwater sources to the Awash River. Hence the Bureau has set up a program for monitoring the water quality of the Awash River. The laboratory facility has also been upgraded for this purpose. The monitoring program encompasses eleven sites stretching from Tefki (source of the Awash) to Metahara. A number of sampling sites for this survey are along the Little and Great Akaki Rivers and Lake Aba Samuel. So far the monitoring team has sampled the rivers during three seasons with a fourth run to be made recently (in August 2005). The output of the survey will be a seasonal report on the water quality of the rivers sampled. This would be valuable information for the treatment procedures to be used in order to utilize the river water for drinking purposes.

- ***Ethiopian Science and Technology Commission (ESTC)-*** The Ethiopian Cleaner Production Centre (ECPC) is a project under ESTC and is responsible for introducing and promoting cleaner production techniques in the country. The ECPC, as an environmental services provider, has currently set up a laboratory to be used by the industries it intends to support. Capacity for measuring various parameters, including those for measuring the production efficiency of industries, will be available at the laboratory. Currently, a technical team at the centre assists a number of industries through various assistance mechanisms including the introduction of cleaner production techniques and the development of environmental management plans. As a service provider the centre also plans to build up the capacity of its laboratory services for utilization at the national level.

- ***Addis Ababa Water and Sewage Authority*** is responsible for constant follow-up and monitoring the quality of the drinking water quality supplied

to the city of Addis Ababa through a centralized piped network. The Authority is also responsible for monitoring sewage and the sewerage treatment facilities in the city. Laboratory facility and technical expertise is also available for carrying out the analysis of water samples. Currently the Authority provides water quality analysis services to many institutions requiring its services. At the present the monitoring program at the Authority mainly focuses on the quality of drinking water supplied to the population of Addis Ababa and has only limited monitoring of streams, rivers, springs and other natural water bodies.

- ***Addis Ababa City Administration Health Bureau*** regularly monitors the quality of drinking water in the city of Addis Ababa. The bureau also undertakes an assessment of the sewage disposal facilities. In this regard laboratory facilities for measuring water pollutants, namely microbiological tests and tests for metals are available. The institution also works closely with most hospital based laboratories in Addis Ababa. A team of experts in the Environmental Health Department in collaboration with the Ministry of Health undertake routine sanitation surveys to monitor the waste that is generated from a number of sources including hospitals, hotels and research facilities is properly disposed. Clinics and other health service providers also require permit of compliance from the Bureau to foster the services they provide.

- ***The Awash Basin Water Resources Administration Agency (ABWRAA)-*** is established as an autonomous public agency to administer the available water resources of the Awash Basin and regulate the flow of water in the rivers of the Basin. The Agency has a Board and a General Manager that is appointed by the Minister of the Ministry of Water Resources. Among the responsibilities of ABWRAA is its mandate to monitor the water quality of the Awash River. Currently the Agency undertakes regular monitoring of the water quality of the rivers in the Basin. So far the program focused on the lower catchments of the River

Basin. However there is major interest by the Agency to extend the current program of the Upper Basin (Communication, Head of ABWRAA).

- ***Ethiopian Nutrition and Health Research Institute (ENHRI), Quality and Standards Authority in Ethiopia (QSAE) and the Ethiopian Geologic Survey (EGS) of the Ministry of Mines*** have laboratories that can be used for measuring a wide range of pollutants. Currently these institutions provide such laboratory services at a national level. Furthermore, unlike most other organizations, the laboratories in these institutions have the capacity to measure pollutants in a variety of environmental matrices including sediments, water and living organisms.

- ***Jimma University (JU) and Arba Minch Water Technology Institute (AWTI)*** are academic institutions with major interest in the environmental issues of the country. JU is well known for its advanced level training in environmental health and sanitation while AWTI for its program in water resources management and specialized training for water laboratory technicians. Currently the AWTI is providing a number of technical services to a major trans-regional water resources management program, *Nile Basin Initiative*.

A listing on the pollutants measured at the laboratory facilities of some of these institutions is elaborated in Appendix 8.

3.4. SUMMARY

Until recently, the number of surface water quality measurement activities in the Awash River Basin has been very limited. Regular monitoring efforts were also non-existent (Benoist 2002). Our listing of studies on the water quality issues of the Awash River Basin shows that almost all these studies lasted only one year or were just single surveys with no follow-up (Appendix 9). However, our current survey of the major environment, health, research and water sector institutions in Ethiopia, indicates that major improvements are being made in this regard. Currently most of these institutions have a conducive organizational framework,

better trained technical manpower and laboratory facilities for the regular monitoring of the water quality of these rivers. In fact, most have already started implementing water quality monitoring programmes on the Awash and Akaki Rivers.

However, most of these monitoring efforts have not been systematic. For instance, only a few of the survey programmes are assisted by GIS assisted database that combines information on the level of pollution along the Awash River at accurately benchmarked sampling locations. Such an accurate pinpointing of the sampling sites is of extreme importance since it sets the grounds for regular monitoring of pollution levels of river water. There has also been very limited statistical manipulation of the already available survey data. Thus the level of output, i.e. research reports, awareness programmes, etc, based on the available data has been very limited. Although most institutions have the capacity for monitoring, they lack the critical manpower and laboratory services to make seasonal assessment of the water quality of the river.

4. PAST AND CURRENT ACTIVITIES AND PROGRAMMEMES RELATED TO THE AKAKI RIVER

There is high environmental pressure on the water resources of the Akaki Rivers due to both sectoral and cross-sectoral factors. Thus any effort to find lasting solutions to these problems requires the participation of various relevant organizations in a coordinated approach. So far, although various institutions have implemented water resources conservation and protection programmes the results have not been satisfactory.

Currently several water resources management projects and programmes are being implemented on the Akaki River by local and international institutions. Below are highlights of the major on-going activities to improve the water quality of the Akaki River.

- The *Environmental Protection Authority of the City of Addis Ababa* is implementing several projects with direct relevance to the Akaki River. This includes the upgrading of the water quality-monitoring programme on the River. Intensive solid waste management projects including organic composting activities and the development of biogas plants are also major activities that are ongoing (Appendix 9).

- Apart from this, the *Addis Ababa City Administration* is undertaking intensive activities to improve housing and solid waste management in the city. In collaboration with a number of partner institutions, including the Addis Ababa University, private sector institutions and NGOs/Civil-Societies the City Government is also setting up activities that would ultimately improve the water quality of the Akaki River. In this regard:

    - A Memorandum of Understanding has been signed between the City Government and the *Addis Ababa University (AAU)*. To that effect, in collaboration with the Biology Department of the AAU, the City Government plans to develop a botanical garden in Addis Ababa. The relevant faculties of the university are also to provide technical assistance in various areas, including the analysis and monitoring of water quality, the development of mitigation measures and the evaluation of their implementation. One particular area of collaboration that has been identified is capacity building in research and training (including trainings in laboratory technology).

    - Through the *Clean and Green Addis Ababa Society* the City Administration is also developing recreation parks along the banks of the Kurtume and Kebena rivers (both tributaries of the Akaki). In particular, the Blue Kebena Riverside Park Development Project is a major project which is currently in its implementation phase. Such a project can thus give a lot of practical experiences, which would contribute to the success of the Akaki River Initiative.

    - In collaboration with private counterparts the city administration is also active in improving solid waste collection and disposal. Apart

from improvement in solid waste management, this has also created employment opportunities for the urban youth. Although figures are not available, many of the contracted firms are involved in composting organic waste.

- The City Administration is also active in the installation of public latrines and development of parks in different parts of the city.

- The *Federal Environmental Protection Authority*, together with other mandated institutions, has prepared provisional environmental quality standards, including those pertaining to water quality. This document will provide the cornerstone for improving the water quality of the Akaki River. The Authority is also active in monitoring the water quality of the Awash River. The outcome of this study will be a seasonal monitoring report of the Awash River and its tributaries. Currently the Authority also has an initiative on the Akaki Rivers underway. Although it is spearheaded by Federal EPA the regional environmental bureaus (Addis Ababa EPA and Oromia EPO) are involved as partners. Currently a joint team of experts from the three organizations are developing an action plan for implementing pollution control and mitigation measures. It is therefore very important to work in close collaboration with such ongoing programs in order to enhance the output of the initiative described in this report.

- The *Ethiopian Cleaner Production Centre*, together with partner institutions including Federal EPA, Addis Ababa EPA, and the Quality and Standards Authority of Ethiopia, is introducing and promoting cleaner industrial production techniques. This programme is organized in such a way that the respective industries benefit from implementing cleaner production techniques. One benefit is certification that would allow industries to compete internationally (ISO 14001 Certification).

- The *Oromia Environmental Protection Office* has currently undertaken epidemiological and socio-economic surveys in woredas situated in downstream locations of the Akaki. As discussed earlier these communities utilize the river for various purposes. The study is

revolutionary in its attempt to quantify (in economic terms) the consequential effects of the pollution of the Akaki River in communities utilizing its water for various purposes.

- The *Oromia Water Resources Bureau* is also undertaking a water quality monitoring program in the Region. As several major towns in the Region utilizes the Awash River (after treatment) for drinking purposes, it has become crucial for the Bureau to regularly monitor the water quality of the rivers in the Basin. Similar to the undertaking of the Federal EPA the outcome of this study will also be a seasonal monitoring report of the Awash River and its tributaries.

A comprehensive listing of the various studies and guideline documents relevant to the pollution of the Awash and Akaki rivers and tributary streams in Addis Ababa is found in Appendix 9. Based on the survey of the consultant the major activities and programmes with relevance to the water quality issues of the Akaki River and their respective outcomes are also elaborated (Appendix 9).

5. STAKEHOLDERS ANALYSIS

The sustainable utilization of the rivers in Addis Ababa and its surroundings would be enhanced if government and other key stakeholders take the environmental issues seriously and become actively involved in promoting, supporting, implementing and evaluating interventions. National strategies, action plans, cost-effective policy instruments, environmental education programmes and the dissemination of knowledge and project results are also important preconditions. A sustainable approach to the water resources of the Akaki Rivers is thus very much dependent on education, institutional capacity building (for monitoring and assessing pollution), legal structures and the involvement of the public in the development process. Concerning the implementation of the integrated management plan for the Akaki, a large number of partners are expected to become involved. This will include governmental and private sector

institutions, local communities and individuals, civil societies and non-governmental organizations (NGOs) and external support agencies.

Governmental Organizations: The implementation of the integrated water resources management plan for the Akaki Rivers will not only involve responsible/mandated institutions but also other important research and service providing governmental institutions. However, the responsible institutions will have the principal roles as they have the implementation capacity and mandate to undertake such an endeavor (refer to Appendix 5). The input of research and academic institutions will also be of utmost importance. Regarding the sustainable management of the resources of the Akaki River, the role of the identified stakeholders (which are mainly from governmental institutions) is summarized below.

Major stakeholders for implementing the Akaki River Initiative

A. Institutions with responsibilities in the water quality issues of Ethiopia[5].

EPA The Federal Environmental Protection Authority has the power to develop and enforce quality standards. The basis is the proclamation on Environmental Pollution Control – that also deals with the development of environmental standards – and in which the EPA, in consultation with other competent authorities, is given the mandate to develop standards "based on scientific and environmental principles and their practical applicability".

MoWR The Ministry of Water Resources– as a federal government organization – has among others the mandate to "prevent pollution of water ….." This is of special relevance because it concerns trans-regional rivers like the Akaki, which flows through the Addis Ababa and Oromia regions.

MoH The Ministry of Health is involved in the monitoring and management of water- borne diseases throughout the country. It is also responsible for developing measures to ensure environmental sanitation and hygiene at the community level.

Regional EPAs Addis Ababa and Oromia-based regional EPAs play a role in collecting water-samples and in the selection of sampling sites. As these agencies have knowledge of the regional problems and accessibility of the rivers their role can be instrumental in planning the

[5] The institutions are ranks as per their mandates in the water quality issues of the Akaki River and their potential for implementing the initiative (ranking is top-down). Detailed mandates and responsibilities of these institutions is found in Appendix 5.

logistics for the program. Apart from this the institutions also have the mandates to develop and implement environmental standards taking Federal EPA's standard as a starting reference base.

AAWSA The Addis Ababa Water and Sewage Authority is responsible for providing adequate and safe water supply, provision of wastewater facilities, wastewater treatment and emptying of septic tanks and pit latrines. As sewage type discharge is a major source of pollution of the Akaki Rivers technical assistance from the AAWSA in these aspects will be essential.

MoTI The Ministry of Trade and Industry will provide the project with information on the location, types and productivity of industries that discharge their wastewater and solid wastes into the Akaki.

ABWRAA The Awash Basin Water Resources Administration Agency can complement the initiative on the Akaki sub-basin with information on the whole catchment areas (Awash Basin).

B. Institutions with responsibilities for research and support services on the water quality issues of Ethiopia[6]*.*

AAU As the primary academic and research institutions in the country the Addis Ababa University has the technical capacity for analysing a variety of samples. The institution also has trained manpower with experience in the different environmental issues of the Akaki River and their mitigation. Hence collaboration with Addis Ababa University can greatly contribute to the success of the Akaki River Initiative. Currently, AAU provides technical support to the City Government of Addis Ababa and the Addis Ababa EPA among others.

ECPC The Ethiopian Cleaner Production Centre of the Ethiopian Science and Technology Commission can assist the Initiative in developing a framework for supporting cleaner industrial production.

EHNRI The Ethiopian Health and Nutrition Research Institute is an institute that has public health laboratories which are being utilized by governmental ministries, industries, the private sector, etc. It will be a partner in the Akaki River Initiative.

QSAE The Quality and Standards Authority of Ethiopia has utilities for laboratory testing of chemicals and microbiological parameters of water samples. The institution is also

[6] The institutions are ranks as per their mandates in the water quality issues of the Akaki River and their potential for implementing the initiative (ranking is top-down).

active in promoting cleaner production techniques.

EGS The Ethiopian Geologic Survey also a major laboratory service provider in Ethiopia. In particular the laboratory is well known for its facilities for testing trace elements in water.

Private Sector Institutions: The involvement of the private sector in such large-scale development programmes has been limited so far. Currently efforts are underway to incorporate the private sector in the various initiatives that are ongoing with regard to the pertinent environmental issues of the country. One example has been the collaboration between the City Government of Addis Ababa and the Addis Ababa Chamber of Commerce in improving solid waste management of the city.

Regarding the pollution of the Akaki River, a fair share of the pollutant industries are privately owned. Even though, most of the ongoing effort focuses on reducing the level of waste generated from government owned industries. It is therefore important to set up a framework to assist also privately owned industries in improving their production techniques. Close collaboration with organized private sector associations, such as the Chamber of Commerce and the Ethiopian Manufacturing Industries Association (EMIA), will contribute greatly to the success of the Initiative.

It is also to be noted that there is a number of Private Sector Consultancy Firms that work on various environmental issues of the country. ECO-CONSULT, WAAS International PLC and Addis Resources Development PLC (ARDCo) are only a few of the consultancy firms that undertake such studies. Identifying and collaborating with such firms will only enhance the output of such an Initiative.

Non-Governmental Organizations: Presently, more than 100 NGOs are involved in the water sector in Ethiopia. Their activities range from project identification to implementation and financing. Most of these NGOs are involved in developing domestic water supplies for rural communities. Only a small fraction, such as Enda Ethiopia and WaterAid, are actively involved in pollution

related research. Among their strong points most NGOs in Ethiopia are very efficient in disseminating information and awareness creation at all levels of the society, especially at the grassroots level. In this regard NGOs can play a central role in the environmental education programmes the Initiative is intending to undertake. Some NGOs that work at the grassroots level can also assist the Initiative by ensuring the participation of the local community at all levels of the planned activities.

Local Communities: Both individuals and communities should have an important share in the development and implementation of the Akaki River Initiative. So far, decision making in the various environmental issues of Ethiopia has not been participatory. However as the ultimate beneficiaries, communities along the rivers will be responsible to help monitor and manage their water resources in the long run. It should therefore be an integral part of this initiative to involve communities as initiators, implementers and/or owners of projects during all phases of its development. The Initiative should also provide these communities with the training required for the management of water resources.

External Support Agencies: Various external support agencies have been actively involved in the major environmental issues of Ethiopia. UNEP for one has been active in Ethiopia in launching a number of initiatives in various environmental issues of the country. The World Bank, UNIDO, UNDP, USAID, JICA, the Royal Netherlands Embassy, Sida, CIDA and other like-minded donor institutions have already implemented major projects related to the development and management of water resources. Technical assistance and financial support are two areas where these agencies need to play a central role.

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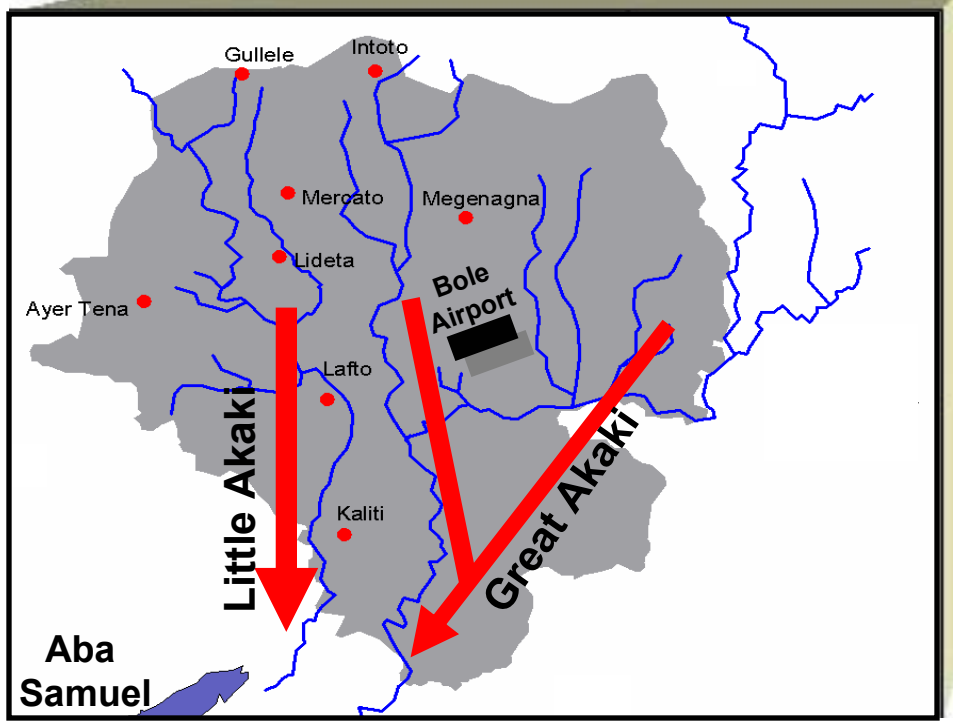
PERSONAL COMMUNICATIONS

1. The Addis Ababa City Administration Health Bureau
   - Dr. Bereket, Head of Laboratory.
2. Addis Ababa Environmental Protection Authority
   - Ato Getachew Eshete, Head of Organization
   - Ato Tekle Wolde Gerima, Head of Environmental Management and Control Department.
3. Addis Ababa University
   - Faculty of Science
     - Dr. Araya, Dean of Faculty.
     - Dr. Tamiru Alemayehu, Department of Geology
     - Dr. Feleke Zewge, Department of Chemistry
     - Dr. Fisseha Itanna, Department of Biology
   - Faculty of Social Sciences
     - Dr. Mulugeta Fiseha, Institute for Development Research (IDR)
   - Faculty of Technology
     - Dr. Nurilign, Head of Chemical Engineering Department
4. Clean and Green Addis Ababa Society
   - Anonymous
5. Dynamic Sanitary Service (DSS)
   - W/t Eden Melke, Head of DSS
6. Ethiopian Cleaner Production Center (ECPC) of the Ethiopian Science and Technology Commission (ESTC)
   - Ato Debebe Yilma, Acting Head, ECPC
7. Ethiopian Health and Nutrition Research Institute (EHNRI)
   - Ato Assefa Desta, Head of Public Health Laboratory.
8. Federal Environmental Protection Authority
   - Ato Mohammed Ali, Head, Pollution Control Department.
   - Dr. Aynalem, Expert, Pollution Control Department
   - Ato Yigzaw Ayalew, Head of Laboratory.
9. Institute for Sustainable Development
   - Ms. Sue Edwards, Director

10. Ministry of Health
    - Anonymous, Department of Hygiene and Environmental Sanitation
11. Ministry of Water Resources (MoWR)
    - Ato Yohannes Gebre Medhin, Head of Water Resources Administration and Urban Water Supply and Sanitation Department
    - Ato Abiy Girma, Expert in Water Resources Administration and Urban Water Supply and Sanitation Department
12. Oromia Environmental Protection Office
    - Ato Siraj Barkelie, Head of Organization
13. Oromia Health Bureau
    - Anonymous
14. Oromia Water Resources Bureau
    - Dr. Daniel Wayessa, Head of Laboratory
15. United Nations Environment Program (UNEP)
    - Dr. Desta Mebratu, Industrial Officer, UNEP Head Quarter
16. United Nations Industrial Development Organization (UNIDO).
    - Ato Gashaw Gebeyehu, National Program Coordinator, Integrated Program for Ethiopia.

FIGURES

Figure 1: Location map of the study area



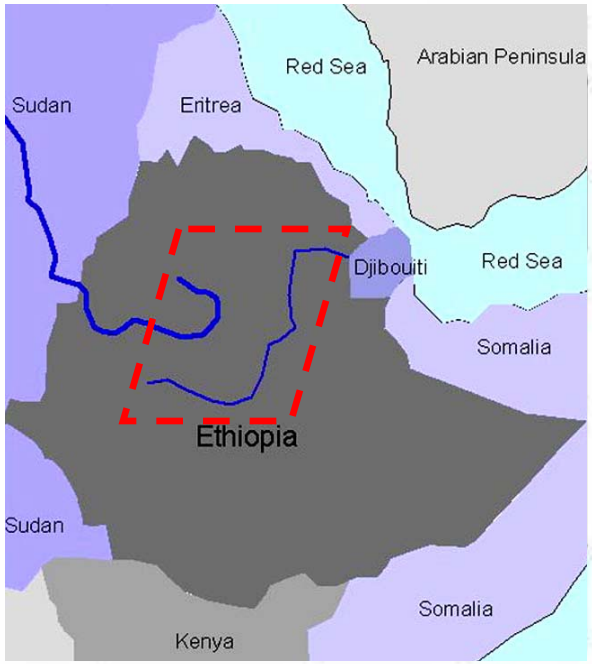


Figure 2: The city of Addis Ababa and its surrounding

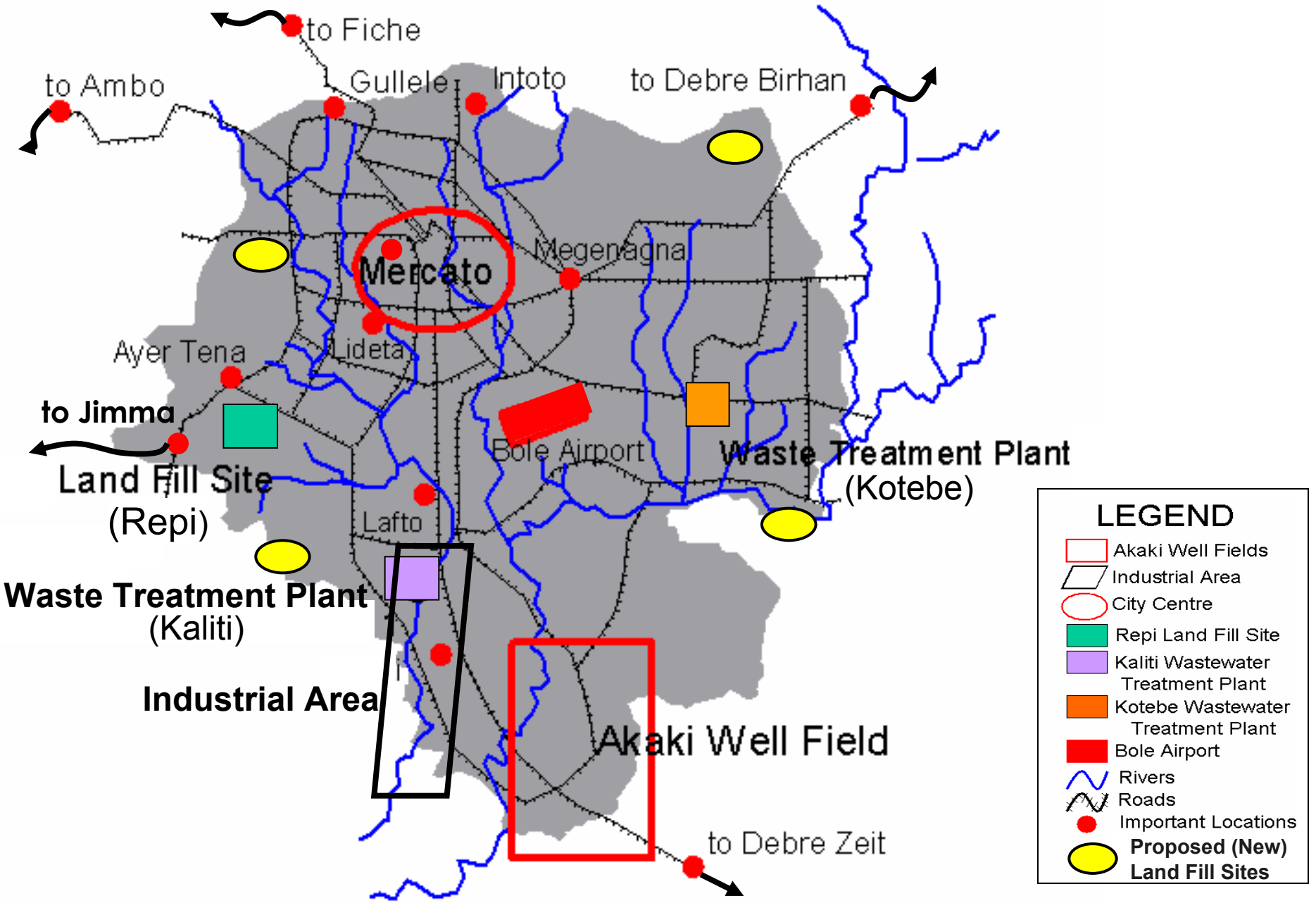


Figure 3: Waste from industrial (tannery) and domestic (litter) sources polluting the Akaki river

APPENDICES

APPENDIX 1: COMMENTS PRESENTED BY THE STAKEHOLDERS AT THE CONSULTATIVE FORUM ON THE 'PROGRAMME FOR SUSTAINABLE CONSUMPTION AND PRODUCTION IN AKAKI RIVER BASIN" HELD ON 6-7 JUNE 2005 IN ADDIS ABABA.

	Comments on Draft Situation Analysis	Improvement in the Final Version
1	The consultant discusses pollution from limited sources. Consider other sources also.	Available information on other sources is incorporated in the current document. This includes domestic households, industries, petrol stations, agriculture, health facilities and garages are elaborated up on. Two important sectors where information is missing, **hotels** and **laundries** are also indicated as areas for future surveys.
2	Try to quantify the contribution of the different sources to the pollution of the Akaki River.	The consultant did not find sufficient data to quantify the contribution of the different sources.
3	Present quantitative figures on level of the different pollutants.	The level of different pollutants in the different environmental matrices is presented in **Appendix 3.**
4	Legislation aspect is not comprehensive i.e. all relevant policies and legislations are not incorporated.	In the current document the Ethiopian water resources management regulations (of the MoWR) and Industrial pollution prevention and control regulations (of the EPA) are discussed in addition to the pollution control and EIA legislation of the EPA. The codes for relevant legislations, policies and regulations are also presented in **Appendix 4**
5	Some Problems like septic tank overflow and discharging of household waste are not elaborated.	Based on available information the situation is discussed in **Section 2 under Domestic Sewage**
6	Mention and elaborate on the Federal EPA draft environmental quality standards	The draft quality standard is discussed in the main report. Relevant parts of the quality standard are also found in **Appendix 10**
7	Discuss on the new land fill sites that are planned to be established.	Based on information available from Dr. Tamiru Alemayehu and a document of the Addis Ababa City Administration, *CITY DEVELOPMENT PLAN 2001-2010*, the situation is discussed under **Section 2-Municipal Solid Waste.**
8	Exhaustively look at other initiatives to create synergy. The Kebena Initiative for instance is one.	Two main initiatives, i.e. an initiative of the Federal EPA on the Akaki River and that of the Clean and Green Addis Ababa Society on the Kebena are discussed.
9	Questionnaire focuses only on trained manpower in laboratory skills. It should also consider the availability of technical skill in other aspects	Based on the survey most stakeholder institutions have indicated that they require capacity building in several technical aspects. Hence the consultant has indicated the need for capacity building as per the feedback from the stakeholder institutions.
10	Include Awash River Basin Development Agency as a stakeholder and review its activities	The agency is included as a stakeholder in this document
11	Update some information as it is outdated	The consultant has still utilized outdated information in cases where there was no other alternative. One instance is the data from a report of 1982 (NOR Consultants) on the percentage contribution of solid waste by the different sources
12	Prioritize the stakeholders based on mandates and implementation capacity.	The stakeholders are prioritized as per the request at the Consultative Forum.
13	Include studies and projects about buffer zone creation and resettlement	Consultant did not find sufficient Information on these aspects.
14	Information on the Great Akaki and the tributary rivers is limited. These rivers should be given due attention	Available information on the Great Akaki is presented in this document. The level of different pollutants in the river is also presented in **Appendix 3**.
15	Estimate on the population affected by the different pollutants and sources	Some available statistics on the population affected is presented in different section of the main report of this document.

APPENDIX 2A: POLLUTION LOADS OF INDUSTRIAL EFFLUENTS FROM SAMPLE INDUSTRIES IN ADDIS ABABA AND THE SURROUNDINGS.

	Name of Industry	pH	SS	DS	BOD_5	NO_3^-	Sulfur	Chloride
1	Addis Soft Drinks	11.7	94	2,880	581.5	0	40.65	0
2	Awash Winery	7.46	3,249	2,923	112,768	9	40.5	25
3	Meta Abo Brewery	5.27	429.3	211	12,169.5	3.75	0	20
4	Moha Soft Drinks	12.3	157.5	4,393	407.5	13.5	277.5	32.5
5	National Alcohol and Liquor	7.91	2,345	1,383.5	13,550	0.2	2.5	4
6	St. George Brewery	6.64	36	62	55	1.05	5.95	5
7	Addis Gas and Plastic	8.27	13	9,087.5	13.5	1.6	12.95	785.23
8	Addis Tyre	8.89	272.5	895.5	24.65	2.7	2,646.25	675
9	Chora Gas and Chemicals	10.1	27,670	3,720	85	0	8.86	16
10	Equatorial Plants	8.3	3,616	41.5	575.5	0	312.5	52.5
11	Gullele Paint	13.5	205.5	89,650	57,231.5	200	80	3.5
	Nefas Silk Paint	6.58	3,612.5	165.5	228.5	23.75	350	7.5
12	Repi Soap	9.0	321.5	1,990	1,034	7	25	52
13	Addis Machine Tools	8.24	31.5	645.5	16.6	6.7	213	70
14	Akaki Spare Parts	6.74	262	411.5	11	7.65	25.95	57.5
15	Akaki Metal Products	2.75	93.5	3,540	73	11	20.3	1,220
16	Ethiopia Metal Foundry	7.51	40.5	292	13	11.12	24.2	12.5
17	Kaliti Metal Products	8.64	157	304.5	165	7.0	87.8	27.6
18	Addis Tannery	9.45	1,350.5	4,089.5	2,428.5	113.75	1,520	150
19	Awash Tannery	3.80	664.5	17,425	914	6.25	1,576.25	11,500
20	Tikur Abay Tannery	8.27	1,365	12,850	1,673.5	14.4	959.5	200
21	Dire Tannery	5.96	1,615	11,920	2,782	375	3,276.5	18,750
22	Hafeda Tannery	7.73	709.5	13,400	985.5	6.85	250.87	60
23	Walia Tannery	10.5	997	5,250	1,648	17.64	144.7	175
24	Akaki Textile	9.07	159.5	966	259.5	50	57.85	116.5
25	Edget Yarn	10.3	54.5	251.5	81.5	5.0	29.8	9
26	Nefas Silk Thread	8.01	86	303	10	3.1	17.55	24

1. **Source:** Desta M. (2000). National Project on Ecologically Sustainable Industrial Development (ESID), Industrial Environmental Policy and Strategy of Ethiopia, Volume 1, Situation Analysis, UNIDO, Addis Ababa.

APPENDIX 2B: THE TOXIC EFFECTS OF COMPOUND USED BY THE DIFFERENT INDUSTRIES SITUATED IN ADDIS ABABA AND THE SURROUNDINGS.

Chronic toxicity		Acute toxicity	Miscellaneous
Genotoxic, Mutagenic and carcinogenic	Reproductive, teratogenic and embryotoxic	Irritation and Dermatitis	
• 2,4-D, DI-Methyl-Amine **S** • Butadiene **Tn*** • Chromium **Tn** • Chromium oxide **Tn** • Formaldehyde **S & T** • Hydrogen Peroxide **T & Tn** • Natural Rubber (probable) **Ty** • Nitrobenzene **Tn** • N-Nitroso-diphenylamine **Ty** • Pentachlorophenol **Tn** • Phenol **Tn** • Poly-vinyl chloride (PVC) **Pl** • Silicone Dioxide (probable) **Ty** • Sodium Bisulphite **Tn** • Sodium Fluoride **Tn** • Sulfuric acid **S**	• 2-(Cyclo-Hexylaminothio) benzothiazole **Ty** • 2,4-D, DI-Methyl-Amine **S** • Acetone **Tn** • N-Butyl acetate **Tn** • Pentachlorophenol **Tn** • Sodium Hydroxide **S** • Sodium P-Decyl-benzene **Tn** • Zinc Oxide **Ty**	• 4-(Isopropyl-amino)-Diphenyl-amine (dermatitis) **Ty** • Ammonium hydroxide **T** • Calcium Carbonate **Ty** • Calcium Resinate **Pp** • Dichlorobenzenes **Tn** • Isopropanol (dermatitis) **Tn & Ty** • Mica powder **Ty** • N-Butyl acetate **Tn** • Sodium carbonate **T** • Sodium Hydroxide **Tn** • Sodium Sulfide **Tn** • Stearic Acid **Ty** • Tin **Plf** • Trichlorobenzene **Tn**	• Nitrobenzene (Methaemaglobia, upsets milk production) **Tn** • Sodium Bicarbonate (alkalosis) **Tn** • Sulfur (phytotoxic and toxic to ruminants) **Ty** • Sulfuric acid (attacks enamel) (26) **S & Tn** • Trichlorobenzene (enhance metabolic activation) (48) **Tn**

* Alphabets in bold and underlined indicate the sub-sector under which the compound are used

Pl-Plastic industry	T-Textile industry	S-Sugar industry	Pp: Pulp and Paper
Plf-Plastic and Foam industry	Tn-Tannery	Ty-Tyre industry	

Properties and health effects of the industrial compounds were mainly retrieved from an Internet link (http://toxnet.nlm.nih.gov/) and the reference texts (Sullivan et al, 1992; IARC, 1981; IARC, 1990; IARC, 2000).

APPENDIX 3- THE LEVEL OF DIFFERENT POLLUTANTS IN THE STREAMS IN AND AROUND ADDIS ABABA.

A. Coliform Count-is used as an indicator for detecting the presence of other potentially harmful bacteria.

A.1. SOLOMON TALE, 2000

Sample location	Sample Type	Coliform Organisms/ 100ml*	Date of Sampling
Little Akaki River (upstream)	Surface water	***Greater than 161****	April 2000
Bantikitu River (city center)	Surface water	***Greater than 161****	April 2000
Kebena River (near city center)	Surface water	***Greater than 161****	April 2000
Little Akaki River (city center)	Surface water	***Greater than 161****	April 2000
Little Akaki River (downstream)	Surface water	***Greater than 161****	April 2000
Big Akaki River (downstream)	Surface water	***Greater than 161****	April 2000
Ras Mekonnen Spring	Groundwater	***Greater than 160****	April 2000
Lideta Spring[1]	Groundwater	***Greater than 160****	April 2000
Abo Spring	Groundwater	Nil	April 2000
Building College, AAU (Lideta)	Groundwater	***10***	April 2000
Dawera Guda (Aba Samuel)	Greater than	***Greater than 160****	April 2000

* According to the World Health Organization (WHO) drinking water guideline (1996), Total Coliform standard limit is set at **10 Total Coliform/lit** while E. Coli in water must not be detectable in any 100ml of water sample. Figures indicated in Bold and Italic fonts are above this guideline level.

** Indicates that Escherichia Coli Type I is present in the samples.

A.2. TAMIRU ET AL, 2004

Sample location	Sample Type	Total Coliform/lit	Escherichia Coli	Date of Sampling
Little Akaki River (upstream)	Surface water	***2.4 x 10^4***	***2.4 x 10^5***	May 2003
Little Akaki River (downstream)	Surface water	***3.5x 10^6***	***3.5 x 10^6***	May 2003
Big Akaki River (upstream)	Surface water	***170***	***2***	May 2003
Big Akaki River (downstream)	Surface water	***5.4 x 10^5***	***2.4 x 10^5***	May 2003
Lideta River (Tributary of Little Akaki River)	Surface water	***5.4 x 10^6***	***5.4 x 10^6***	May 2003

***** According to the World Health Organization (WHO) drinking water guideline (1996), Total Coliform standard limit is set at **10 Total Coliform/lit** while E. Coli in water must not be detectable in any 100ml of water sample. Figures indicated in Bold and Italic fonts are above this guideline level.

[1] Temporal assessment in bacteria population in the Lideta spring shows that the Total Coliform was the highest in April (during the small rain *'Belg'*) while E. Coli count was highest in May (Source Tamiru et al, 2004).

B. Biological Oxygen Demand* indirectly measures the level of oxygen available in water. This oxygen is required for the proliferation of aquatic species. High BOD_5 level indicates low oxygen level in water.

B.1. TAMIRU ET AL, 2004

Date of Sampling	Little Akaki Upstream	Little Akaki Downstream	Big Akaki Upstream	Big Akaki Downstream	Lideta River (Tributary of Little Akaki)***
May 2003	5.6	1.2	***6.4***	3	***100***
July 2003	1.4	***18***	0.9	***6.6***	***20***
August 2003	1.3	***14***	1.8	2	***24***
October 2003	2.2	***11.2***	1	***6.1***	***29.3***
November 2003	***58****	***20***	***6.3***	***7.3***	***61***
December 2003	2.7	***14***	***9***	***33***	***226***
January 2004	***7.2***	***12***	***8.5***	***28.3***	***55***
February 2004	3.5	***23***	***13***	3.6	***76***
March 2004	4	***56***	***25***	***17***	***136***

* Several countries have set BOD_5 values at **6mg/l**. This level is set as a guideline for maintaining a health ecosystem (Teklehaimanot, 2003). Figures indicated in Bold and Italic fonts are above this guideline level.

** Except for the anomalous value in November, in the Little Akaki River, BOD level are higher in downstream location. This shows the contribution of the activities in and around Addis Ababa for the pollution of the Little Akaki.

*** The extremely high pollutant load that is received by the Little Akaki can also be clearly seen from the BOD level in the Lideta River, i.e. a tributary of the Little Akaki.

B.2. TEKLEHAIMANOT, 2003

Date of Sampling	Little Akaki Downstream	Big Akaki Downstream	Bulbula River (Tributary of the Great Akaki)	Mekanissa River (Tributary of the Great Akaki)	Lake Aba Samuel
June 2002	***30.8***	***10.2***	***31.2***	***11.73***	4.4

* Several countries have set BOD_5 values at **6mg/l**. This level is set as a guideline for maintaining a health ecosystem (Teklehaimanot, 2003). Figures indicated in Bold and Italic fonts are above this guideline level.

B.3. TAMIRU, 2000

Little Akaki (surface water)

Sampling Date	Tributary of Little Akaki (near Asko Shoe Factory)	Little Akaki River (near ALERT Bridge)	Little Akaki River (after Medhane Alem High School Bridge)	Little Akaki near Mekanissa Bridge	Little Akaki near Mekanissa Liquor Factory Bridge	Little Akaki inlet to Aba Samuel Lake	Outlet from Aba Samuel Lake
March 1997	***8***	***8***	***301***	***19***	***254***	***321***	0.8

Great Akaki (surface water)

Sampling Date	Kebena River at French Embassy	Kebena at Bole Bridge	Big Akaki inlet to Aba Samuel	Outlet from Aba Samuel Lake
March 1997	***11***	***29***	***13***	0.8

* Several countries have set BOD_5 values at **6mg/l** (Teklehaimanot, 2003). This level is set as a guideline for maintaining a health ecosystem (Teklehaimanot, 2003). Figures indicated in Bold and Italic fonts are above this guideline level.

** BOD levels were measured in surface water samples

B.4. ADDIS ABABA UNIVERSITY (MSc Program, Graduate Course in Environmental Pollution and Control), 2003

Sample location	BOD_5 Level (mg/lit)	Date of Sampling
Burayu and Gefersa after mixing (upstream)	2.7	December 2002
Akaki River before mixing with Addis Ababa Tannery (upstream)	5.8	December 2002
Akaki after mixing with effluent of Addis Ababa Tannery (upstream)	***137.6***	December 2002
Zenebework stream and Akaki after mixing	***8.9***	December 2002
Akaki and Kera River after mixing	***60.7***	December 2002
Akaki and Lafto River after mixing (downstream)	***91.2***	December 2002
Akaki and Jajo after mixing (downstream)	***62.2***	December 2002
Akaki after mixing with Adey Ababa garment factory effluent (downstream)	***39.8***	December 2002
Akaki after mixing with Saris liquor factory effluent (downstream)	***204.5***	December 2002
Akaki close to the Jima Road (downstream)	***89.2***	December 2002
Akaki before joining Aba Samuel (downstream)	***31.1***	December 2002

* Several countries have set BOD_5 values at **6mg/l** (Teklehaimanot, 2003). This level is set as a guideline for maintaining a health ecosystem. Figures indicated in Bold and Italic fonts are above this guideline level. BOD was measured in surface water samples

B.5. ENVIRONMENTAL PROTECTION AUTHORITY, 2003*.

	RIVERS AND SAMPLING LOCATIONS	BOD_5
1	**Little Akaki River and its tributaries**	
	Before Gullele Soap Factory	3.5
	Near Building College	***339****
	Zenebework Area	***40***
	Fifth Police Station Bridge	***535***
	Abatoir Area	***444***
	Near Bihere Tsige Park	***252***
	Downstream near Kaliti waste water treatment plant	***105***
2	**Kebena,. Kurtume and other streams**	
	Kurtume near Habte Giorgis Bridge	***93***
	Kurtume Main Post Office area	***134***
	Near Zewditu Hospital	***144***
	Near Kechene Bridge	***36***
	North of French Embassy	***11***
	Misrak High School area	***63***
	Urael Bridge	***24***
	Bole Bridge	***60***
3	**Great Akaki River**	
	Near Legedadi Dam	5
	End of Bole area	***32***
	Near Akaki Bridge	***10***

* **Source:** State of the Environment Report, Environmental Protection Authority, 2003

** Several countries have set BOD_5 values at **6mg/l**. This level is set as a guideline for maintaining a health ecosystem (Teklehaimanot, 2003). Figures indicated in Bold and Italic fonts are above this guideline level.

C. Nitrite*- The excess level of nitrite causes a health disorder known as methaemoglobia.

C.1. TAMIRU ET AL 2004

Date of Sampling	Little Akaki** Upstream	Little Akaki Downstream	Big Akaki Upstream	Big Akaki Downstream	Lideta River (Tributary of Little Akaki)***
May 2003	0.05	<0.008	<0.008	0.06	<0.008
July 2003	0.1	0.25	<0.008	0.22	***2***
August 2003	0.07	0.55	0.01	0.17	0.27
October 2003	0.096	0.48	0.02	0.92	<0.008
November 2003	0.01	0.6	0.01	0.25	<0.008
December 2003	0.06	0.96	0.01	0.54	<0.008
January 2004	0.02	0.71	0.15	0.52	<0.008
February 2004	0.03	0.01	0.02	0.56	<0.008
March 2004	<0.008	<0.008	<0.008	0.26	<0.008

* The WHO has set **1mg/lit** (Nitrite as Nitrogen), as a health oriented guideline in drinking water. Figures indicated in Bold and Italic fonts are above this guideline level.

** Nitrite levels were measured in surface water samples

C.2. TEKLEHAIMANOT 2003

Date of Sampling	Little Akaki ** Downstream	Big Akaki Downstream	Bulbula River (Tributary of the Great Akaki)	Mekanissa River (Tributary of the Great Akaki)	Lake Aba Samuel
June 2002	1.5	1.31	9.92	1.16	0.14

* The WHO has set **1mg/lit** (Nitrite as Nitrogen), as a health oriented guideline in drinking water. Figures indicated in Bold and Italic fonts are above this guideline level.

** Nitrite levels were measured in surface water samples

D. Heavy Metals: Excess levels (and in some cases deficiencies also) cause a variety of health complications in humans and aquatic species.

D.1. FISSEHA 2002

D.1.1. Metal levels in *LEAFY VEGETABLES*[a] grown, in farms around Kera and Peacock, using the polluted waters of the rivers in Addis Ababa.

Element, mg/kg	Cabbage		Lettuce		Swiss Chards		Recommended Maximum Limit for Vegetables*
	Kera	Peacock	Kera	Peacock	Kera	Peacock	
Arsenic (As)	0.13	0.11	***1.04****	0.31	***1.21***	0.34	0.43
Cadmium (Cd)	0.02	0.01	0.13	0.08	0.08	0.04	0.2
Cobalt (Co)	0.06	0.13	0.76	0.17	0.68	0.32	50
Chromium (Cr)	0.89	1.61	***9.47***	1.21	2.05	1.04	2.3
Copper (Cu)	3.03	3.3	6.62	6.24	8.06	7.88	73.3
Iron (Fe)	73.0	173.0	***1345.0***	351.0	***527.0***	***461.0***	425.5
Lead (Pb)	0.21	0.29	***1.59***	***1.59***	***1.79***	***0.61***	0.3
Manganese (Mn)	29.0	25.0	106.0	106.0	37.5	67.0	500
Nickel (Ni)	0.8	0.91	1.86	1.86	2.1	0.89	67.9
Zinc (Zn)	31.8	31.81	48.63	48.63	56.19	48.91	99.4

[a] Sampling was carried out in December 1998.
* The recommended maximum limit was obtained from Fisseha 2002.
** Figures indicated in Bold and Italic fonts are above the recommended maximum limit.

D.1.2. Metal levels in *RIVER WATER SAMPLES*[a], adjacent to farms at Peacock and Kera that grow leafy vegetable using the polluted waters of the rivers in Addis Ababa.

Element, ug/kg	Bulbula River (ug/lit)	Kera River (ug/lit)	Guidelines for Maximum Level in Irrigation Water*
Arsenic (As)	1.7	<1.0	100
Cadmium (Cd)	0.07	<1.0	10
Cobalt (Co)	2.69	<5.0	50
Chromium (Cr)	Not determined	7.4	550
Copper (Cu)	12.40	***39.0*** **	17
Iron (Fe)	Not measured	***4290.0***	500
Lead (Pb)	14.1	33.0	65
Manganese (Mn)	Not measured	***1690.0***	200
Nickel (Ni)	2.26	8.9	1400
Zinc (Zn)	50.37	193.0	2000

[a] Sampling was carried out in December 1998.
* The recommended maximum limit was obtained from Fisseha 2002.
** Figures indicated in Bold and Italic fonts are above above the recommended maximum limit.

D.1.3. Metal levels in *SOIL SAMPLES*[a], adjacent to farms at Peacock and Kera that grow leafy vegetable using the polluted waters of the Akaki Rivers.

Element, mg/kg	Bulbula River (mg/kg)	Kera River (mg/kg)	Guidelines for Maximum Level in Soil*
Arsenic (As)	5.19	6.80	20
Cadmium (Cd)	0.71	0.44	3
Cobalt (Co)	27.95	43.0	50
Chromium (Cr)	81.0	***115.0*** **	100
Copper (Cu)	38.96	55.0	100
Iron (Fe)	163.86	79.70	50000
Lead (Pb)	46.74	***110.0***	100
Manganese (Mn)	***6587.0***	***3598.0***	2000
Nickel (Ni)	***74.13***	***115.0***	50
Zinc (Zn)	***2985.5***	263.0	300

[a] Sampling was carried out in December 1998.
* The recommended maximum limit was obtained from Fisseha 2002.
** Figures indicated in Bold and Italic fonts are above above the recommended maximum limit.

D.2. TEKLEHAIMANOT 2003[a]

Element (ug/lit)	Little Akaki downstream	Great Akaki downstream	Lake Aba Samuel	EUMAC* value
As	2.3	1.3	0.7	10ug/lit
Cr	***99****	<0.5	<0.5	50ug/lit
Pb	<0.3	***30***	<0.3	10ug/lit

[a] Sampling was carried out in November 2001 and samples were measured in surface water
* European Union Maximum Acceptable Concentration in drinking water.
** Values indicated in bold and italic are above guideline limits set by EU for drinking water.

D.3. TAMIRU 2000[a]

Sampling Site	Sample Type	Arsenic (As) (ug/lit)	Chromium (Cr) (ug/lit)	Lead (Pb) (ug/lit)
Kolfe Stream near Bihere Tsige	Surface water	2.3	14.1	0
Kebena Stream, upstream	Surface water	1.24	0	0
Kebena, near German Embassy	Surface water	0	0	0
Kebena near Urael Church	Surface water	0.59	0	0
Kechene Stream, upstream	Surface water	1.005	5.76	7.873
Kechene near Ras Mekonnen Bridge	Surface water	0.126	0	0
Kechene near Zewditu Hospital	Surface water	0.096	0	0
Addis Gebeya spring	Spring	0	0	0
Lideta spring	Spring	0.9979	1.88	0
Ras Mekonnen Bridge spring	Spring	0	1.18	0
Yeka North, spring	Spring	0	0	0
Guideline level	-	10 (EUMAC)	50 (EUMAC)	10 (EUMAC)

[a] Sampling was carried out in June 1999

D.4. BIRHANU 2002

- Chromium is found elevated in the Little Akaki River (near Akaki bridge), with a value of 182ug/lit. EU guideline, i.e. Maximum Acceptable Concentration, for chromium is **50ug/lit**.
- Lead, Arsenic and Cadmium were not found to be a problem.

D.5. SAMUEL 2005

D.5.1. Heavy metal level in *SURFACE WATER SAMPLES* from the streams in and around Addis Ababa.

Sample location	Cadmium (ug/lit)		Chromium (ug/lit)		Lead (ug/lit)	
	Campaign I*	Campaign II*	Campaign I	Campaign II	Campaign I	Campaign II
Burayu and Gefersa after mixing (upstream)	0.009	0.016	0.32	0.43	0.059	0.5
Akaki River before mixing with Addis Ababa Tannery (upstream)	0.006	0.004	0.34	0.45	0.057	0.17
Akaki after mixing with effluent of Addis Ababa Tannery (upstream)	0.024	0.032	***110.9******	***264.2***	3.36	0.09
Akaki and Kera River after mixing	0.011	0.031	1.41	1.67	2.66	0.35
Akaki and Lafto River after mixing (downstream)	0.007	0.011	1.72	1.29	0.144	0.141
Akaki and Jajo after mixing (downstream)	0.037	0.023	2.06	2.06	0.15	1.11
Akaki after mixing with Saris liquor factory effluent (downstream)	0.021	0.034	2.69	2.43	3.28	1.34
Akaki close to the Jima Road (downstream)	0.017	0.074	11.26	***54.22***	0.235	4.71
Akaki before joining Aba Samuel (downstream)	0.018	0.051	3.07	8.51	0.159	1.3
Typical natural trace element concentration in river water**	0.02		1		3	
EUMAC Values (ug/lit)	3		50		10	

* Campaign I was carried out between November and January 2002-2003, While Campaign II was carried out between November and January 2003-2004.

** Source: **Samuel 2005, Pp20.**

*** Values indicated in bold and italic are above guideline limits set by EU for drinking water.

D.5.2. Heavy metal level in *SEDIMENT SAMPLES* from the streams in and around Addis Ababa.

Sample location	Cadmium (ug/lit) dry weight		Chromium (ug/lit) dry weight		Lead (ug/lit) dry weight	
	Campaign I*	Campaign II*	Campaign I	Campaign II	Campaign I	Campaign II
Burayu and Gefersa after mixing (upstream)	0.319	0.305	***86.3****	***104.3***	22.07	21.78
Akaki River before mixing with Addis Ababa Tannery (upstream)	0.213	0.334	***112.8***	***142.9***	20.3	31.1
Akaki after mixing with effluent of Addis Ababa Tannery (upstream)	0.281	0.316	***15355***	***16254***	***82.4***	***125.0***
Akaki and Kera River after mixing	***1.613***	***1.047***	***161.3***	***236.8***	***325.4***	***637.9***
Akaki and Lafto River after mixing (downstream)	***0.919***	***0.640***	***136.4***	***180.9***	***131.4***	***340.6***
Akaki and Jajo after mixing (downstream)	***1.036***	0.563	***135.8***	***137.6***	***223.8***	***346.8***
Akaki after mixing with Saris liquor factory effluent (downstream)	***0.669***	0.399	***198.8***	***213.8***	***137.5***	***103.4***
Akaki close to the Jima Road (downstream)	0.460	0.419	***272.3***	***252.6***	***190.4***	***208.7***
Akaki before joining Aba Samuel (downstream)	0.493	0.420	***247.0***	***204***	***138.0***	***118.6***
Typical natural trace element concentration in soil and sediment**	0.25		60		20	
CCME* Guideline Limits (ug/lit)**	0.596		37.3		35	

* Campaign I was carried out between November and January 2002-2003, While Campaign II was carried out between November and January 2003-2004.

** Source: **Samuel 2005, Pp20.**

*** Interim freshwater sediment quality guidelines (dry weight) for the protection of aquatic species, established by the Canadian Council of Ministers of the Environment (CCME).

**** Values indicated in bold and italic are above guideline limits set by EU for drinking water.

E. Xenobiotics: Excess levels cause a variety of health complications in humans and aquatic species.

E.1. TEKLEHAIMANOT 2003[a]

E.1.1. Level of toxic compounds in *SEDIMENT SAMPLES* from the streams in and around Addis Ababa

COMPOUNDS	Little Akaki Downstream	Big Akaki Downstream	Bulbula River (Tributary of the Great Akaki)	Mekanissa River (Tributary of the Great Akaki)	Lake Aba Samuel
Dioxin like compounds[b]	5.4	1.6	<lod*	1.3	<lod
Poly aromatic hydrocarbons[c]	51.07	99.95	65.21	4.57	10.26
Estrogen like compounds[d]	143.66	3.5	8.56	7.03	2.21

[a] Sampling was carried out in June 2002.

[b] The level of dioxin like compounds is expressed in **pgTEQ/g of wet sediment** *(pico gram of 2,3,7,8-Tetrachlorodibenzodioxin, i.e. TCDD, Equivalent per gram of wet sediment)*. TCDD is the most toxic of the compounds that elicit dioxin like effects. The level of dioxin like compounds was measured using the 24 hours DR CALUX test (refer to **Teklehaimanot 2003** for details of the procedure).

[c] The level of poly aromatic hydrocarbons is expressed in **ngBEQ/g of wet sediment** *(nano gram of Benzo(a)Pyrene, i.e. B(a)P, Equivalent per gram of wet sediment).* B(a)P is the most toxic of the group of compounds i.e. polyaromatic hydrocarbons. The level of polyaromatic hydrocarbons was measured using the ER CALUX test (refer to **Teklehaimanot 2003** for details of the procedure).

[d] The level of estrogen like compounds is expressed in **pgEEQ/g wet sediment** *(pico gram of Estradiol Equivalent per gram of wet sediment).* Estradiol is commonly used as a reference for quantifying estrogen like compounds. The level of estrogen like compounds was measured using the 6 hours DR CALUX test (refer to **Teklehaimanot 2003** for details of the procedure).

* Level is below **limit of detection (lod)**.

E.1.2. Level of dioxin like compounds in BIOTA SAMPLES from the streams in and around Addis Ababa.

Sampling Site	Sample Type	Dioxin like Compounds[b]
Little Akaki Downstream	Tubifex Tubifex (worm species)	1342.3
Big Akaki Downstream	Tubifex Tubifex (worm species)	24.2
Bulbula River (Tributary of the Great Akaki)	Tubifex Tubifex (worm species)	45.5
Mekanissa River (Tributary of the Great Akaki)	Tubifex Tubifex (worm species)	<lod
Lake Aba Samuel	Clarias Batrachus (Catfish)	31.7 (muscle)[c], 15.4 (liver)[c], 3.3 (bile)[c]

[a] Sampling was carried out in June 2002.

[b] The level of dioxin like compounds is expressed in **pgTEQ/g of lipid** *(pico gram of 2,3,7,8-Tetrachlorodibenzodioxin, i.e. TCDD, Equivalent per gram of lipid)*. TCDD is the most toxic of the compounds that elicit dioxin like effects. The level of dioxin like compounds was measured using the 24 hours DR CALUX test (refer to **Teklehaimanot 2003** for details of the procedure).

[c] Muscle, liver and bile were sampled from the catfish species.

***** Level is below **limit of detection (lod)**.

Note

Concerning human health the WHO (WHO, 1999) has established a Tolerable Daily Intake (TDI) level of 1-4pg TEQ/Kg of body weight for exposure to dioxin like compounds via food consumption. Taking the average human body weight to be 65 Kg, it can be said that persons consuming greater than 1.4-4.5gram[2] of catfish daily from Lake Aba Samuel are in a risk zone **(Teklehaimanot, 2003)**.

[2] The level of TCDD in the catfish sample from Lake Aba Samuel is 0.88 pgTEQ/gram (per gram of catfish).

APPENDIX 4- ETHIOPIAN POLICIES, LEGISLATIONS AND REGULATIONS WITH RELEVANCE TO ENVIRONMENTAL MANAGEMENT, POLLUTION AND WATER QUALITY ISSUES.

1. POLICIES

1a. The Environmental Policy for Ethiopia (EPE), 1997.

The EPE incorporates policies covering:

- Soil husbandry and sustainable agriculture
- Forest, woodland, and tree resources
- Genetic, species, and ecosystem biodiversity
- Water resources
- Energy resources
- Mineral resources
- Human settlement, urban environment, and environmental health
- Control of hazardous materials and of pollution from industrial waste
- Atmospheric pollution and climate change
- Cultural and natural heritage.

The EPE also includes cross-sectoral environmental policies on:

- Population and the environment
- Community participation and the environment
- Tenure and access rights to land and natural resources
- Land use planning
- Social and gender issues
- Environmental research
- Environmental impact assessment
- Environmental education and awareness.

(Source: World Bank 2004)

1b. Agriculture Development Led Industrialization (ADLI)

ADLI is developed to achieve rapid and sustainable economic growth by improving the productivity of the agricultural sector. Development in agriculture is to help build up an industrial sectors.

2. LEGISLATIONS

2a. Establishment of Important Organs (Establishment Proclamations)

1. Addis Ababa Waster and Sewerage Authority Proclamation, 1972.
   Ref No: 31/12/ 1972
2. Agreement Concerning the Establishment of a Regional Center for Services in Survey, Mapping and Remote Sensing.
3. Ethiopian Water Works Construction Authority Establishment Proclamation, 1980.
   Ref No: 39/16/ 1980
4. Ethiopian Mapping Agency Establishment Proclamation, 1980
   Ref No: 40/1/ 1980.
5. National Water Resources Commission Establishment Proclamation, 1981.
   Ref No: 41/3/ 1981
6. Water Supply and Sewerage Authority Establishment Proclamation, 1981
   Ref No: 41/3/ 1981
7. Office of the National Committee for Central Planning Establishment Proclamation, 1984.
   Ref No: 41/13/ 1984
8. National Research Institute for Health Establishment Proclamation, 1985
   Ref No: 44/5/ 1985
9. National Urban Planning Institute Establishment Proclamation, 1987.
   Ref No: 46/15/ 1987
10. Ethiopian Valleys Development Studies Authority Establishment Proclamation, 1987
    Ref No: 46/16/ 1987
11. The Environmental Protection Authority Establishment Proclamation, 1995
    Ref No: 9/1995
12. The Awash River Basin Administration Agency Establishment Proclamation, …
    Ref No. 129/1998
13. Environmental Protection Organs Establishment Proclamation, 2002.
    Ref No: 295/2002

2b. Hazardous Compounds

1. Special Decree on Pesticide Control, 1990
   Ref No: 20/1990
2. Pesticide Control Proclamation, 1998
   Ref No: 137/1998

2c. Land Use

1. Urban Dwellers' Association and Urban Administration Proclamation, 1981
   Ref No: 40/15/ 1981

2. Urban Zoning and Building Permit Proclamation, 1987.
   Ref No: 46/15/ 1987

3. Preparation and Implementation of Urban Plans Proclamation, 1987
   Ref No: 46/15/ 1987

2d. Public Health Protection

1. Municipal Public Health Rules, 1950.
   Ref No: 10/1/ 1950
   - Municipal Public Health Rules (Water Rules), 1950.
   - Municipal Public Health Rules (Refuse Rules), 1950
   - Municipal Public Health Rules (Disposal of Dead Bodies Rules), 1950

2. Municipal Sanitation Rules, 1951.
   Ref No: 10/12/ 1951

3. Public Safety Welfare Order, 1971
   Ref No: 70/1971

4. Radiation Protection Proclamation, 1993.
   Ref No: 79/1993

2e. Water

1. Water Rules, 1945.
   Ref No: 5/3/ 1945

2. Proclamation for Water Pollution Control, 1981
   Ref No: 217/1981

3. Water Resources Utilization Proclamation, 1994
   Ref No: 53/78/ 1994

4. Ethiopian Water Resources Management Proclamation, 2000
   Ref No: 197/2000

5. Environmental Impact Assessment Proclamation, 2002.
   Ref No: 299/2002

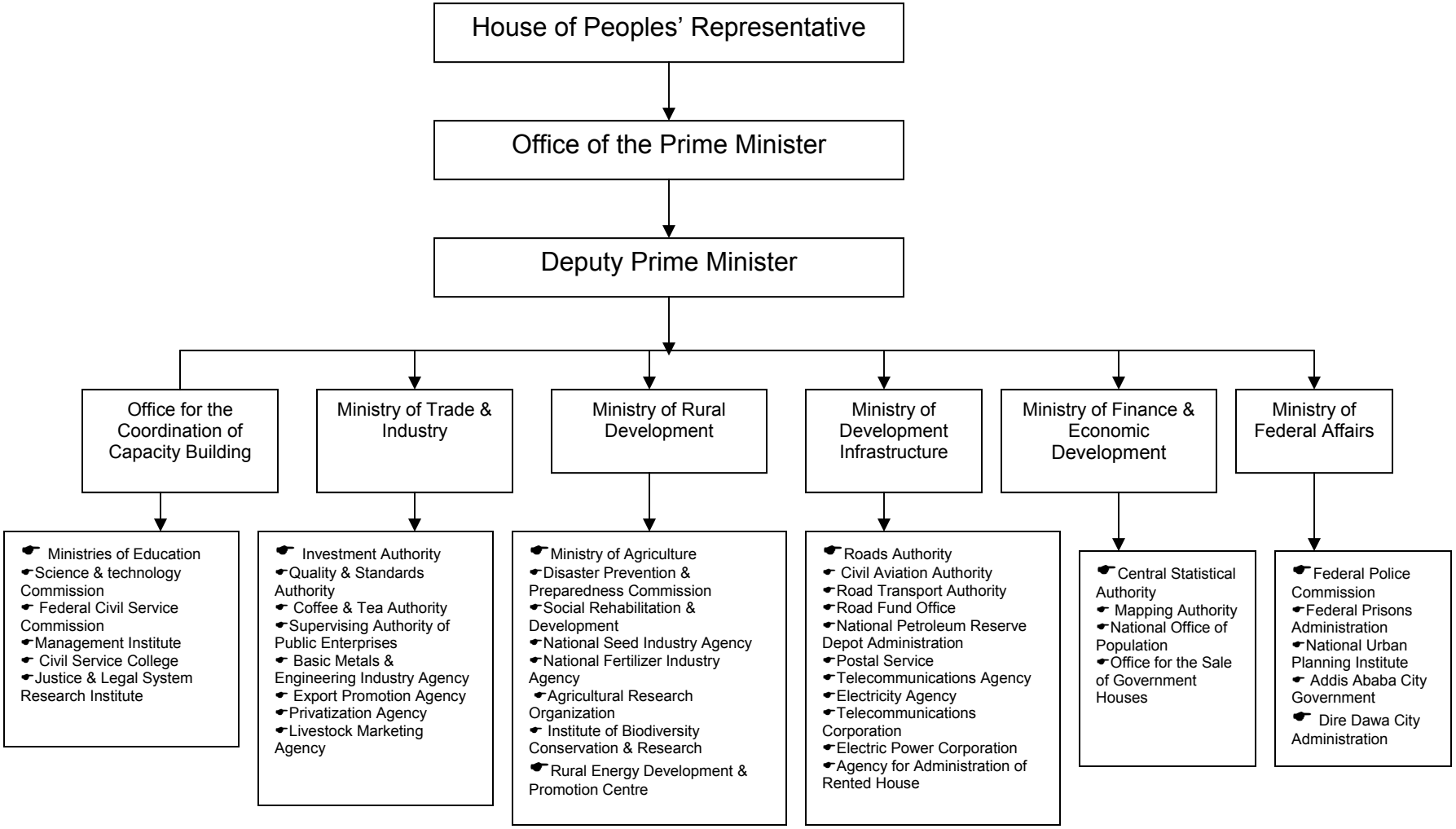
6. Environmental Pollution Control Proclamation, 2002
   Ref No: 300/2002

7. Ethiopian Water Resources Management Regulations, 2005
   Ref No: 115/2005

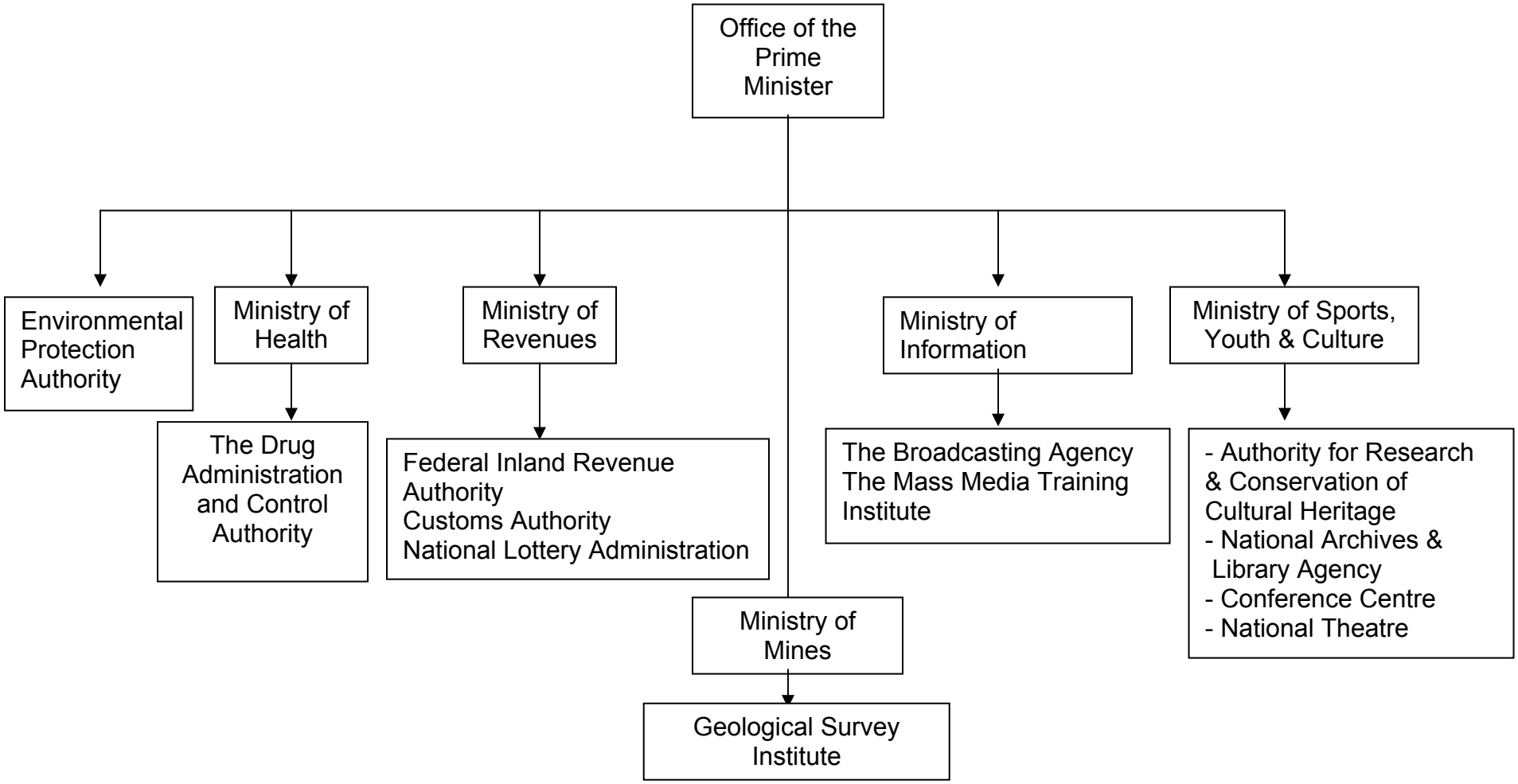
8. Industrial Pollution Prevention and Control Regulations, under review by the Council of Ministers.
   Ref. No: - -/2005

APPENDIX 5: INSTITUTIONAL FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT IN ETHIOPIA

5a. Diagrammatic Representation of the Framework for Environmental Management in Ethiopia.



5a. Continued…



(Source: World Bank, 2004)

5b. The Responsibilities of the Main Agencies in the Ethiopian Government with Environmental Mandates.

	Organization	Responsibilities
1	**Environmental Protection Authority (EPA)**	➢ Monitoring and enforcing the protection of the water resources of the country ➢ Enacting legislations that would enable the monitoring/protection of the water resources of the country. ➢ Performing researches on the different water resource issues of the country ➢ Setting up quality and quantity related standards for the sustainable utilization of the natural resources of the country. ➢ Setting up an environmental information system and overlooking the dissemination of the information ➢ Coordinating the activities of the Regional Environmental Protection Organs. ➢ Representing and promoting the interest of Ethiopia internationally, in environment related issues and events.
2	**Ministry of Water Resources (MoWR)**	➢ Monitoring and enforcing the protection of the water resources in Ethiopia ➢ Enacting policies and legislations that would enable a more efficient utilization of water resources ➢ Providing clean water supply to the Population ➢ Setting up quality and quantity standards for the sustainable utilization of the water resources of the country. ➢ Representing and promoting the interest of Ethiopia in international and regional water resource issues. ➢ Performing researches on the different water resource issues of the country ➢ Setting up an information system and overlooking the dissemination of information.
3	**Ministry of Health (MoH)**	➢ Developing water quality standards for safe consumption by the population ➢ Performing researches on the different public health issues of the country ➢ Supporting the management of Occupational Health and Safety ➢ Undertaking activities of sanitation to prevent and control the occurrence of diseases

5b. Continued…

	Organization	Responsibilities
4	**Ministry of Finance and Economic Development (MoFED)**	➢ Monitoring the overall implementation of the National Environmental Policy ➢ Reviewing all major programmes and projects in the country and ➢ Developing and overlooking the Land Use policy
5	**Ministry of Agriculture and Rural Development (MoARD)**	➢ Developing land and water management schemes in the country ➢ Developing land use policies to promote sustainable utilization of the natural resources and ➢ Managing pesticides and other toxic compounds used in the sector.
6	**Ministry of Trade and Industry (MoTI)**	➢ Controlling and Managing Industrial Waste and Hazardous Materials
7	**Ministry of Labour and Social Affairs**	➢ Handling and storing of toxic and hazardous materials and ➢ Setting and Monitoring the Environmental Health Standards of Workers.
8	**Ministry of Capacity Building**	➢ Mainstreaming environmental concern in the education systems
9	**Ministry of Education (MoE)**	➢ Integrating environmental education in the education system (curriculum) of the country
10	**Ministry of Justice**	➢ Registering all Associations including those with environmental concerns ➢ Following-up and updating information on these Associations
11	**Quality and Standards Authority for Ethiopia (QSAE)**	➢ Developing water quality standards for safe consumption by the population ➢ Strengthening and enhancing the reliability of testing laboratories nation-wide.
12	**Ethiopian Science and Technology Commission (ESTC)**	➢ Commissioning researches on the different environmental issues of the country ➢ Involving in the promotion of cleaner production techniques in the country
13	**Ministry of Mines**	➢ Regulating activities related to mineral prospecting, investigation and production.
14	**Ethiopian Mapping Authority (EMA)**	➢ Developing a geoinformation management system that will support the environmental protection efforts of the country.

5b. Continued…

	Organization	Responsibilities
15	**Addis Ababa Environmental Protection Authority (EPA)**	➢ Monitoring and protecting the water resources of the city of Addis Ababa ➢ Performing researches on the different environmental issues of the city of Addis Ababa ➢ Setting up an environmental information system and overlooking its dissemination. ➢ Developing up quality and quantity related standards for the sustainable utilization of the natural resources of the city of Addis Ababa.
16	**Addis Ababa Water and Sewerage Authority (AAWSA)**	➢ Providing clean water supply to the city of Addis Ababa ➢ Monitoring of the potable water supply the city of Addis Ababa ➢ Developing a sewerage system for the city of Addis Ababa ➢ Collecting and managing sewage and ➢ Performing researches on the different water resource issues in the city
17	**Addis Ababa Health Bureau**	➢ Performing researches on the different water resource issues of the city of Addis Ababa ➢ Undertaking activities to promote sanitation and hygiene in Addis Ababa and ➢ Advising the Addis Ababa City Administration on the various health issues of the city
18	**Oromia Environmental Protection Office (OEPO)**	➢ Monitoring and protecting the water resources of the Oromia Region. ➢ Performing researches on the different water resource issues of the Oromia Region. ➢ Setting up an environmental information system and overlooking the dissemination of the information. ➢ Developing up quality and quantity related standards for the sustainable utilization of the natural resources in the Oromia Region.
19	**Oromia Water Resources Bureau**	➢ Monitoring and enforcing the protection of the water resources in the Oromia Region ➢ Providing clean water supply to the population ➢ Performing researches on the different water resource issues of the Oromia Region ➢ Setting up an information system and overlooking the dissemination of information.
20	**Oromia Health Bureau**	➢ Performing researches on the different water resource issues of the Oromia Region ➢ Undertaking activities to promote sanitation and hygene in the Oromia Region. ➢ Advising the regional administration on the various health issues of the Oromia Region.

APPENDIX 6: IDENTIFIED PROBLEMATIC AREAS FOR THE MANAGEMENT OF WATER RESOURCES IN ETHIOPIA

	Problem Area	Specific Problem	Effect	Remarks
1	Public Participation	Low Public Participation in Decision Making	Intervention measures have not been effective	• Although public participation is addressed in some recent environmental legislation there is still a lack of well-defined framework to ensure public participation.
2	Information and data	Lack of an integrated management information system	Limited information for monitoring the water resources of the country	• There is no standardized procedure for gathering and storing information pertaining to water resources at both the Federal and Regional Level. • At the regional level there is deficiency with regards to maintaining proper data and information records
3	Legislative Aspects	Sectoral Nature of Legislations.	Restrict an integrated and holistic approach in water resources management.	• Legislations do not provide a broad framework under which the enactment could be implemented in an integral and holistic manner.
		Gaps in existing environmental legislation.	Some environmental impacts are not covered by current legislations.	• Public health (environmental health), solid and liquid waste disposal and toxic and hazardous waste management are areas relevant to the water sector that are not adequately covered by existing legislations.
		Lack of water quality standards	Difficult to measure the success and drawback of intervention measures	• Ambient Water Quality Standard does not exist so far. • Quality Standard is also not available for effluent from the different industries

APPENDIX 6: Continued….

	Problem Area	Specific Problem	Effect	Remarks
4	Institutional shortcomings	Management Issues	Shortcomings in implementing capacity	• lack of organizational units at the lowest levels like woreda and zones • inability of the government to retain trained and experienced staff
		Lack of Coordination	Water Resources related efforts could not be enhanced	• No structural and coordinated linkages among institutions interested in the water resource issues of the country.
		Institutional Instability	Complicates the task of institutional capacity building	• Institutions responsible for water resources management undergo restructuring and reorganization frequently
		Overlap in Mandates	Results the repetition of efforts and the wasting of the already scarce resources	• Clear overlap in water-sector regulatory tasks stipulated for EPA and MoWR
5	Capacity and Financial Issues	Capacity and Financial Limitations	Inability to enforce the existing regulations	• Lack of resources including finance, skilled manpower, material and equipment

APPENDIX 7: QUESTIONNAIRE USED TO SURVEY OF INSTITUTIONAL CAPACITY IN MANAGING THE WATER RESOURCES OF THE AKAKI RIVER.

Full name of Institution:

Address:

TEL: FAX:

Email: Website:

1. Institution Type

Mandated	**Research and Academic**

(a) Mandated (what are your mandates with regards to pollution and water resources management).

(b) Research and Academic (what are your activities with regards to pollution water resources management)

2. Capacity Issues

(a) Laboratory Facilities for Water Quality Assessment

Available	**Needed but Not Available**	**Not Needed**

I. If facility is available what type of pollutants are measured (metals, organic pollutants, and other toxic compounds like Pesticides, industrial compounds, etc.)?

Type of Pollutant	**Measured (Y/N)**	**If yes technique used**
Metals		
Organic Pollutants (BOD, COD, NO_2, etc).		
Pesticides (synthetic toxins)		
Industrial Compounds (toxins)		
Others		

II. Technical expertise in this area (number of laboratory technicians involved) and the scale of service (i.e. measure samples on a nationwide scale, regionally, etc).

- Number of Laboratory Technicians?
- Scale of Services

Serves at the National Scale efficiently	Serves at the national scale with shortcomings	Serves at the regional scale efficiently	Serves at the regional scale with shortcomings	Used for internal purposes only but there is capacity to serve others	Used for internal purposes only

III. List of other laboratory service providers the institution works closely with.

International	Local

(b) List of departments related to water quality issues and the activities each of these departments undertake with regards to the pollution problems of the city of Addis and its surrounding and the sustainable utilization its water resources.

Department	Activity

3. Past and present activities relevant to the water resources management of the Awash, Akaki and the Rivers in Addis Ababa **(works on solid waste, effluent management, pollution control, hygiene, etc.)**

(a) Research reports produced?

YES	NO

I. If Yes?

i. An estimate of the number of research reports produced per a certain period of time

ii. A complete listing of the reports including

- Title
- Year

Report Title	Year

(b) Listing of programs and projects implemented so far that focus on the pollution of the Awash, Akaki and rivers in Addis Ababa (Name of project, donors, execution period and outcome)

Name of Project	Execution Period	Outcome

(c) Similar Project and Programs that are being carried out at present and to be carried in the future (Name of Project, execution period and anticipated outcome).

Name of Project	Execution Period	Outcome

4. What could your institutions provide for the sustainable utilization of the water resources of the Akaki Rivers?

APPENDIX 8: WATER QUALITY PARAMETERS MEASURED IN SOME INSTITUTIONS WITH LABORATORY FACILITIES FOR ASSESSING WATER QUALITY.

I. ETHIOPIAN HEALTH AND NUTRITION RESEARCH INSTITUTE (EHNRI)

- Ammonia (NH_3), mg/lit
- Biological oxygen demand (BOD)
- Chemical oxygen demand (COD), as mgO_2/lit
- Chloride (Cl^-), mg/lit
- Colour, true (TCU)
- Fecal and Total Coliform
- Nitrate (NO_3), mg/lit
- Nitrite (NO_2), mg/lit
- pH
- Phosphate (PO_4), mg/lit
- Settleable solids, ml/lit
- Sulphate (SO_4^{2-}), mg/lit
- Total Alkalinity
- Total dissolved solids (at 105°c), mg/lit
- Total fixed solids (at 550°c), mg/lit
- Total solids (at 105°c), mg/lit
- Total suspended solids (at 105°c), mg/lit
- Total volatile solids (at 550°c), mg/lit
- Trace Elements **(details not available)**
- Turbidity, NTU

II. MINISTRY OF WATER RESOURCES (MoWR)

- Alkalinity, CO_3^{2-} and HCO_3
- Ammonia (Nessler)
- Boron
- Calcium
- Chloride
- Colour
- Electrical Conductivity
- Fecal and Total Coliform
- Fluoride
- Iron
- Magnesium
- Manganese
- Nitrate
- pH
- Phosphate
- Potassium
- Sediment Load
- Sodium
- Sulphate
- Total Dissolved Solids
- Total Hardness
- Total Solids
- Turbidity

III. MINISTRY OF MINES

- Aluminum (Al)
- Barium (Ba)
- Boron (B)
- Bromide (Br)
- Cadmium (Cd)
- Calcium (Ca)
- Carbon dioxide (CO_2)
- Carbonate (CO_3^-) and Bicarbonate (HCO_3^-)
- Chloride (Cl^-)
- Chromium (Cr)
- Cobalt (Co)
- Conductivity
- Copper (Cu)
- Faecal Coliforms
- Fluoride (F^-), mg/lit
- Hydrogen Sulfide (H_2S)
- Iodide (I)
- Iron (Fe)
- Lead (Pb)
- Lithium (Li)
- Magnesium (Mg)
- Manganese (Mn)
- Nickel (Ni)
- Nitrate (NO_3), mg/lit
- Nitrite (NO_2), mg/lit
- pH
- Phosphate (PO_4)
- Potassium (K)
- Silica (SiO_2)
- Silver (Ag)
- Sodium (Na)
- Strontium(Sr)
- Total suspended solids, TSS (at 550°c), mg/lit
- Total Coliforms
- Total dissolved solids, TDS (at 105°c), mg/lit
- Zinc (Zn)

IV. ADDIS ABABA UNIVERSITY[3]

- Ammonia (NH_3), mg/lit
- Arsenic (As), ug/lit
- Biological oxygen demand (BOD_5), mg/lit
- Calcium (Ca), mg/lit
- Chemical oxygen demand (COD), as mgO_2/lit
- Chloride (Cl^-), mg/lit
- Colour, true (TCU)
- Chromium (Cr), ug/lit
- Fecal and Total Coliform
- Kjeldhal Nitrogen, mg/lit
- Lead (Pb), ug/lit
- Magnesium (Mg), mg/lit
- Manganese (Mn), ug/lit
- Nickel (Ni), ug/lit
- Nitrate (NO_3), mg/lit
- Nitrite (NO_2), mg/lit
- pH
- Potassium (K), mg/lit
- Phosphate (PO_4), mg/lit
- Settleable solids, ml/lit
- Sediment Load
- Silica (SiO_2), mg/lit
- Sodium (Na), mg/lit
- Sulphate (SO_4^{2-}), mg/lit
- Total Alkalinity, CO_3^{2-} and HCO_3
- Total dissolved solids (at 105°c), mg/lit
- Total fixed solids (at 550°c), mg/lit
- Total solids (at 105°c), mg/lit
- Total suspended solids (at 105°c), mg/lit
- Total volatile solids (at 550°c), mg/lit
- Turbidity, NTU
- Zinc (Zn) ug/lit

Currently a number of laboratory instruments have also been imported to the different departments in the faculty. The automated isotope lab is one such facility available at the Faculty of Science. Apart from this several departments at the faculty also have complex instruments like ion chromatography and atomic adsorption spectrophotometer.

[3]This is a compilation of the parameters measured at the different departments of the Faculty of Science of the Addis Ababa University. The Faculty of Science has a more complex water quality laboratory than the other faculties of the Addis Ababa University.

V. ADDIS ABABA WATER AND SEWAGE AUTHORITY (AAWSA)

- Ammonia (NH_3), mg/lit
- Biological oxygen demand (BOD_5), mg/lit
- Chemical oxygen demand (COD), as mgO_2/lit
- Chloride (Cl^-), mg/lit
- Colour, true (TCU)
- Fecal and Total Coliform
- Kjeldhal Nitrogen, mg/lit
- Nitrate (NO_3), mg/lit
- Nitrite (NO_2), mg/lit
- pH
- Phosphate (PO_4), mg/lit
- Settleable solids, ml/lit
- Sulphate (SO_4^{2-}), mg/lit
- Total Alkalinity
- Total dissolved solids (at 105°c), mg/lit
- Total fixed solids (at 550°c), mg/lit
- Total solids (at 105°c), mg/lit
- Total suspended solids (at 105°c), mg/lit
- Total volatile solids (at 550°c), mg/lit
- Trace Elements **(details not available)**
- Turbidity, NTU

VI. QUALITY AND STANDARDS AUTHORITY IN ETHIOPIA

- Silver (Ag)
- Aluminum (Al)
- Arsenic (As)
- Gold (Au)
- Barium (Ba)
- Borate
- Calcium (Ca)
- Cadmium (Cd)
- Chloride (Cl)
- Cobalt (Co)
- Chromium (Cr)
- Iron (Fe)
- Fluoride (F)
- Mercury (Hg)
- Potassium (K)
- Magnesium (Mg)
- Manganese (Mn)
- Sodium (Na)
- Nickel (Ni)
- Lead (Pb)
- pH
- Selenium (Se)
- Sulphate (SO_4^{2-})
- Total Alkalinity
- Total Dissolved Solids (TDS)
- Total Hardness
- Zinc (Zn)

VII. FEDERAL AND ADDIS ABABA ENVIRONMENTAL PROTECTION AUTHORITIES

- Aluminum (Al)
- Ammonia (NH_3), mg/lit
- Arsenic (As), ug/lit
- Biological oxygen demand (BOD_5), mg/lit
- Calcium (Ca)
- Carbonate (CO_3^-) and Bicarbonate (HCO_3^-)
- Chemical oxygen demand (COD), as mgO_2/lit
- Chloride (Cl^-), mg/lit
- Chromium (Cr), ug/lit
- Copper (Cu)
- Cyanide (CN)
- Dissolved Oxygen (DO)
- Electrical Conductivity (EC)
- Fecal and Total Coliform
- Fluoride (F), mg/lit
- Iron (Fe)
- Lead (Pb)
- Magnessium (Mg)
- Manganese (Mn)
- Nitrate (NO_3), mg/lit
- Nitrite (NO_2)
- pH
- Potassium (K)
- Phosphate (PO_4), mg/lit
- Sodium (Na)
- Sulfides
- Sulphate (SO_4^{2-}), mg/lit
- Total dissolved solids (at 105°c), mg/lit

VIII. OROMIA WATER BUREAU

- Ammonia (NH_3), mg/lit
- Biological oxygen demand (BOD_5), mg/lit
- Chemical oxygen demand (COD), as mgO_2/lit
- Calcium (Ca)
- Chloride (Cl^-), mg/lit
- Chromium (Cr), ug/lit
- Copper (Cu)
- Dissolved Oxygen (DO)
- Electrical Conductivity (EC)
- Fecal and Total Coliform
- Fluoride (F), mg/lit
- Nitrate (NO_3), mg/lit
- pH
- Phosphate (PO_4), mg/lit
- Settleable solids, ml/lit
- Sulphate (SO_4^{2-}), mg/lit
- Total Alkalinity
- Total dissolved solids (at 105°c), mg/lit
- Total suspended solids (at 105°c), mg/lit
- Zinc (Zn)

IX. ETHIOPIAN CLEANER PRODUCTION CENTER

- Biological oxygen demand (BOD_5), mg/lit
- Chemical oxygen demand (COD), as mgO_2/lit
- Flue Gas Analysis

X. ARBA MINCH WATER TECHNOLOGY INSTITUTE

A Water Quality Laboratory is available at Arba Minch Water Technology Institute. However the Consultant does not have information on what parameters are measured at the institute.

APPENDIX 9: A SUMMARY OF POLLUTION RELATED ACTIVITIES ON THE AWASH AND AKAKI RIVERS UNDERTAKEN BY SEVERAL LOCAL AND INTERNATIONAL INSTITUTIONS.

I. LOCAL GOVERNMENTAL ORGANIZATIONS (Mandated)

i. Federal Environmental Protection Authority

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	An Initiative for improving the water quality of the Akaki Rivers.	Since 2005	Improvement of the water quality of the Akaki Rivers.
2	Water quality monitoring program on the Awash River	Since 2002	A water quality monitoring report will soon be available. This is to be a seasonal monitoring report (i.e. four reports per year).
3	Introduction of environmental audit program for industries that discharge their waste in the Akaki River	Since 2002	Outcome report under preparation. Several industries are progressively improving their environmental performance
4	Environmental Impact Assessment Services	Since 2002	Experts in the EIA services department are evaluating the environmental measures planned to be undertaken by new projects with environmental consequences.
5	In collaboration with UNIDO preparation of a documentary film on the sustainable industrial pollution.	2004	Documentary film on the pollution of the Akaki River and the streams in Addis Ababa from industrial pollution.

PUBLICATIONS

	Title	Year	Author
1	Draft ambient environmental standards for Ethiopia	Draft	Federal EPA
2	Draft provisional standards for industrial pollution control in Ethiopia.	Draft	Federal EPA
3	Water quality status report on the Awash River	2004	Federal EPA
4	Industrial pollution and its impacts on the Little Akaki River	2002	Mohammed Ali
5	National profile to assess the national infrastructure for the management of chemicals in Ethiopia	1999	Federal EPA
6	Preliminary water quality assessment on Great Akaki, Little Akaki and Kebena Rivers	1997	Federal EPA
7	The Conservation Strategy for Ethiopia	1996	EPA and MEDaC*

*Ministry for Economic Development and Cooperation

ii. Addis Ababa Environmental Protection Authority

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Upgrading the water quality monitoring program on the Akaki River	Yet to Start	Synthesized information based on the available data from previous surveys on the Akaki River.
2	Model Project on biogas in Addis Ababa and the surrounding	Since 2004	Several biogas plants have started production
3	Organic waste composting project. Pilot project for wastewater treatment using local methods.	Since 2004	Selected household have started composting organic solid waste.
4	Rehabilitation projects of the upper catchments of the rivers in Addis Ababa (Yeka catchment)	Since 2004	Implementation of sustainable land management techniques in sections of the Akaki catchment that is degraded.
5	In collaboration with the ESTC: Assessment of the pollution status of the little Akaki River.	2002	A study report on the pollution of the Akaki River.

PUBLICATIONS

	Title	Year	Author
1	Draft industrial effluent standard for the city of Addis Ababa	Draft	AA EPA
2	Assessment of the little Akaki River water pollution	2002	AA EPA

iii. Oromia Environmental Protection Office

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Survey on the socioeconomic impact of the pollution of the Akaki River.	Since 2002	An assessment report of the survey.

PUBLICATIONS

	Title	Year	Author
1	Assessment of socioeconomic impacts of Akaki River pollution.	2004	Oromia EPO

iv. Ministry Of Water Resources

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	In collaboration with JICA working on the water quality issues of the groundwater resources in Addis Ababa and the surroundings.		

PUBLICATIONS (Ministry of Water Resources Contd')

	Title	Year	Author
1	Water quality monitoring network in Awash Basin: TOR.	2002	MoWR and DHV Ethiopia
2	Water Sector Development Program 2002-2016	2002	MoWR

v. Addis Ababa Water And Sewage Authority

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	USAID supported Project for modifying the sewage treatment plant at Kaliti district.	1999	To build and operate an organic fertilizer factory which will utilize the raw material from the sewage treatment plant.
2	Netherlands government supported construction of wastewater treatment plant at Kotebe.	-	The wastewater treatment plant is operational.
3	Master plan for the development of wastewater facilities in Addis Ababa.	1993	

PUBLICATIONS

	Title	Year	Author
1	A survey report on the current status of sewage systems of Addis Ababa and measures to improve it	1994	Fujiyama JOCV T.
2	Master plan study for the development of wastewater facilities for the City of Addis Ababa. Volume 4: Existing situation and design criteria report	1993	AAWSA, BCEOM and GKW

vi. Oromia Water Bureau

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Awash and tributaries: follow-up of water quality.	2005	A yearly assessment report of water samples collected from the Awash River and tributaries from 11 sites in between Tefki and Metahara.

PUBLICATIONS: Only activity reports at the current time.

vii. Ministry Of Health

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	UNICEF supported Rapid Water Quality Assessment program.	Since 2005	In collaboration with other stakeholders assessing the quality of drinking water in Ethiopia (at a national level).
2	Survey on liquid waste management	1996	

PUBLICATIONS (Ministry of Health Contd')

	Title	Year	Author
1	Study of liquid waste management in the urban centers of Ethiopia.	1996	Life Consult and MoH
2	Health and Health Related Indicators (2003/2004)	2004	MoH

viii. Addis Ababa Health Bureau

PROGRAMS AND PROJECTS: Information not available.

PUBLICATIONS

	Title	Year	Author
1	A comprehensive overview on Addis Ababa municipality solid waste management and its environmental services.	1997	Addis Ababa City Administration Health Bureau

ix. Oromia Health Bureau

PROGRAMS AND PROJECTS: Information not available.

PUBLICATIONS: Information not available.

x. The Ethiopian Valleys Development Study Authority (EVDSA)

PROGRAMS AND PROJECTS: The Authority does not exist currently.

PUBLICATIONS

	Title	Year	Author
1	Master plan for the development of surface water resources in the Awash Basin Vol. 9; Annex M: Environmental health.	1989	EVDSA and Halcrow
2	Master Plan for the Development of Surface Water Resources in the Awash Basin Vol. 9, Annex N: Water Quality.	1989	EDVSA and Halcrow
3	Follow up of the 1974 survey indicated below	1976	Firdu Z.
4	Studies and Assessment of Water Pollution in Awash River and its Tributaries in the Upper Basin.	1974	Komolorit, K. And Firdu Z.

xi. The Ethiopian Cleaner Production Center of the Ethiopian Science Technology Commission

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	EIA Services	Yet to start	Support industries that are yet to be established, design effective mitigation measures at their initial design phase.
2	Transfer of Environmentally Sound Technologies (TEST)	Yet to start	Introduction and promotion of environmentally sound technologies for industries that are yet to be established.
3	Introduction and promotion of Environmental Management System (EMS) and environmental audit.	2003	Improvement of the environmental performance of selected industries. Legal compliance of selected industries through the implementation of EMS.
4	Introduction and Promotion of Cleaner Production (CP) techniques.	2000	Environmental performance of selected industries improved through waste reduction.

PUBLICATIONS: Only activity reports at the current time.

xii. Awash Basin Water Resources Administration Agency

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Water Quality Monitoring Program of the River in the Awash River Basin.		
2	Awash River Basin Flood Control and Watershed Management Study	2004	To generate data and information for the analysis of the technical, social and economic issues important for the formulation of and effective and sustainable flood control and watershed management projects in the Awash Basin.

PUBLICATIONS: Only activity reports at the current time.

II. LOCAL GOVERNMENTAL ORGANIZATIONS (Academic and Research)

i. Addis Ababa University

- **Faculty of Science**

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	In collaboration with Addis Ababa EPA the Department of Biology of AAU is to develop a botanical garden in Addis Ababa.	Yet to start	
2	Agreement with important stakeholders, including AA EPA, to provide laboratory facilities and technical assistance in various areas of environmental pollution.	Yet to start	
3	Graduate program (M.Sc. Degree) in Environmental Sciences.	Since 2002	The Faculty of science offers a master's degree in environmental science. The program provides various courses in Pollution Control.
4	Various research projects and publications on the pollution of the Akaki River	See publication listing below	

PUBLICATIONS

	Title	Year	Author
1	Water Quality Assessment and Groundwater Vulnerability Mapping in Addis Ababa Water Supply Aquifers. UNEP/UNESCO report.	In Progress	Tamiru A et al. (Department of Geology)
2	The Environmental Status of the Little Akaki River (partial fulfillment for the course in Environmental Pollution and Control-En.Sc. 615)	2003	Term paper for M.Sc. students in Environmental Sciences.
3	Metal in leafy vegetables grown in Addis Ababa and their toxicological implications, Ethiop J. Health Dev. 16; 295-302	2002	Fisseha, I (Department of Biology)
4	The Impact of Uncontrolled Waste Disposal of Surface Water Quality in Addis Ababa. SINET: Ethiopian Journal of Science 24(1): 93-104.	2001	Tamiru A. (Department of Geology)
5	Effects of Uncontrolled Waste Disposal of Surface and Ground Water Quality System in Addis Ababa: A Case Study. Ethiopian Herald	Tuesday 01/08/2000	Tamiru A (Department of Geology)
6	Water Pollution by Natural Inorganic Chemicals in the Central Part of the Main Ethiopian Rift. SINET: Ethiopian Journal of Science, 23(2): 197-214.	2000	Tamiru A. (Dept.of Geology)
7	Water Pollution in Addis Ababa. Ethiopian Herald.	Wedesday 19/05/1999	Tamiru A. (Dept. of Geology)
8	Water Quality and Groundwater/Akaki River Interaction in the Sekelo Basin (Lower Akaki Sub-Basin), M.Sc. thesis.	1999	Aynalem A. (Department of Geology)
9	Comparative study on Soil Pollution with toxic substances on farmlands close to old and new industrial sites in Ethiopia, Department of Biology, AAU.	1998	Fisseha, I (Department of Biology)

- **Faculty of Social Sciences**

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Graduate programs in Rural Development and the Environment, Environmental Economics, and Environment and Development in the Department of Geography, Economics, and Institute of Development Research respectively.	Since 2003	Various departments at the Faculty of Social Science have started master's degree program in rural development, environmental economics and environmental science.
2	The Department of Geography and the Institute of Development Research have worked on various researches related to the environmental issues of the Akaki Rivers.	See publication listing below	-

PUBLICATIONS

	Title	Year	Author
1	Waste management in Addis Ababa: case study of the practice, problems and issues in Lideta Sub-city. Research Paper for the M.A. program in Environment and Development, AAU.	2005	Shewangezaw S. (Institute of Development Research)
2	Urbanization and environmental concern in Addis Ababa. Research Paper for the M.A. Program in Environment and Development, AAU.	2005	Megdelawit T. (Institute of Development Research
3	Urban green area management in Addis Ababa with special reference to public parks. Research Paper for the M.A. Program in Environment and Development, AAU	2005	
4	Little Akaki: A study in water quality variations of an urban river system. M.A. Thesis. AAU.	1989	Lemma B (Department of Geography)
5	Open access water resource management for sustainable development: The case of Little and Great Akaki Rivers, *in Population, Sustainable use of Natural Resources and Development in Ethiopia, Bekure W. & Singh, K.N.(eds.)*, Journal of the Association of Ethiopian Geographers, Addis Ababa	1996	Yohannes B. (Department of Geography)

- **Faculty of Medicine**

PROGRAMS AND PROJECT-Information not available

PUBLICATIONS

	Title	Year	Author
1	Chemical, physical, and microbiological characteristics of water in and around Addis Ababa. *Ethiopian Journal of Health Development,* 13(3), 239-246.	1999	Yesehak W., Sinknesh E., Worku E. and Leykun J. (Department of Biochemistry)
2	Some chemical constituents of selected water sources in and around Addis Ababa and Ambo, *Ethiop. J. Health Dev.; 8(2): pp97-102.*	1994	Yesehak W. and Sinkenesh E. (Department of Biochemistry)

- **Faculty of Technology**

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Graduate programs in Environmental Engineering under the Department of Chemical Engineering.	Since 2003	The Department of Chemical Engineering has started a master's degree program in environmental engineering.
2	Various collaborations between the Chemical Engineering Department and other important stakeholders in the design of wastewater treatment plants.	See publication listing below	-
3	The Department of Civil Engineering is active in design and construction water supply lines and wastewater treatment plants.	See publication listing below.	-

PUBLICATIONS

	Title	Year	Author
1	Addis Ababa Water Supply Stage Iii-A Project	1998	Ijigneh Sime (Department of Civil Engineering)
2	Investigation of the effluents from the Akaki Textile factory and design pf a wastewater treatment plant	1996	Dr. Ing. Habil. K Graichen and Ato Techome Worku (Department of Chemical Engineering).
3	Tannery Wastewater Treatment and Recovery Plant Design: Case of Awash Tannery. B.Sc. Thesis, Chemical Engineering Department, Addis Ababa University, Addis Ababa.	1995	Getachew A. (Department of Chemical Engineering)
4	Industrial Waste: Its Management and Pollution Impact in Ethiopia. B.Sc. Thesis, Chemical Engineering Department, Addis Ababa University, Addis Ababa.	1990	Desta M. (Department of Chemical Engineering)

ii. College of Urban Planning

PROGRAMMES AND PROJECTS: Information not available.

PUBLICATIONS

	Title	Year	Author
1	*Study of Addis Ababa Rivers: The Case of Kurtume River*. Graduation Paper: College of Urban Planning, Addis Ababa.	1990	Abdi Y., Bede B., Wondimu A.

iii. Ethiopian Civil Service College

PROGRAMMES AND PROJECTS: Information not available.

PUBLICATIONS

	Title	Year	Author
1	GIS and Its Application in Alleviating Urban Environmental Problems: The Case of Waste Management in Addis Ababa, Thesis for B.Sc. in Town Planning, Ethiopian Civil Service College, Addis Ababa.	1997	Tefera Sileshi

iv. Arba Minch University of Water Technology

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Advance level trainings (advance Diploma and B.Sc. Degree) in sanitary & environmental engineering and water resources engineering. A two year diploma program also provides trainings for water laboratory technicians.		

PUBLICATION: Information not available

v. Jimma University

Environmental Health Department

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Advanced level trainings (diploma and B.Sc degree) in environmental health. The program focuses on basic environmental issues like controlling the quality of water, food and air, on site work and community protection against toxic substance and the disposal of wastes.		

PUBLICATIONS

	Title	Year	Author
1	Assessment of Factors Contributing to the Eutrophication of Aba Samuel Water Reservoir in Addis Ababa, Ethiopia		Worku Legesse

III. NON GOVERNMENTAL ORGANIZATION

(b) Enda Ethiopia

PROGRAMMES AND PROJECTS: Information not available.

PUBLICATIONS

	Title	Year	Author
1	The Cycle of Waste in Addis Ababa, Research Component, Draft.	1999	Enda Ethiopia and Preceup

(c) Water Aid

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Host of the Ethiopia Country Water Partnership (ECWP) which promotes the principles and approaches of Integrated Water Resources Management (IWRM)	Since 2003	-

PUBLICATIONS: Information not available.

(d) Clean and Green Addis Society

PROGRAMS AND PROJECTS

	Program/ Project	Period	Outcome
1	Blue Kebena Riverside Park Development Project	2005-2006	-
2	Kurtume Riverside Project	2005-2006	-

PUBLICATIONS (Clean and Green Addis Society Contd')

	Title	Year	Author
1	Blue Kebena Riverside Park (Proposed Design)	2005	Clean and Green Addis Society

IV. INTERNATIONAL ORGANIZATIONS (UN and other Donor Agencies)

i. Food and Agricultural Organizations

PROGRAMS AND PROJECTS: Information not available

PUBLICATIONS

	Title	Year	Author
1	Report on Survey of the Awash River Basin. Vol.1, General Report, Rome.	1965	FAO

ii. United National Industrial Development Organization

PROGRAM

	Title	Year	Author
1	Report on Survey of the Awash River Basin. Vol.1, General Report, Rome.	1965	FAO

PUBLICATIONS

	Title	Year	Author
1	National Project on Ecologically Sustainable Industrial Development (ESID), Industrial Environmental Policy and Strategy of Ethiopia, Volume 1, Situation Analysis.	2000	Desta M. (UNIDO)

iii. Japan International Cooperation Agency (JICA)

PROGRAMS AND PROJECTS: Information not available

PUBLICATIONS

	Title	Year	Author
1	Country profile on environment, Ethiopia.	1999	JICA

iv. Royal Netherlands Embassy

PROGRAMS AND PROJECTS: Information not available

PUBLICATIONS

	Title	Year	Author
1	Environmental management in Ethiopia: An overview	2002	ECO-CONSULT

v. The World Bank

PROGRAMS AND PROJECTS: Information not available

PUBLICATIONS

	Title	Year	Author
1	A Country Environmental Analysis (CEA): Institutional Analysis to Enhance Environmental Management	2004	-
2	Rapid Stocktaking of Environmental Health. Prepared as background note for the Ethiopian CEA.	2002	Doumani, F
3	Ethiopia: Environment Update	2000	Bojo J. and Segnestam L.

V. INTERNATIONAL ORGANIZATIONS (Academic and Research)

PUBLICATIONS

	Title	Year	Author
1	Investigation of input and distribution of polluting elements in Tinishu Akaki River, Ethiopia, based on the determination by ICP-MS	2005	Samuel Melaku Abegaz (University of Ghent, Belgium)
2	Toxic Risk Evaluation of the Awash River Basin, Ethiopia	2003	Teklehaimanot R.R (Wageningen University, the Netherlands)
3	A literature based study into the expected pollution of the Awash River, Ethiopia	2003	Teklehaimanot R.R (Wageningen University, the Netherlands)
4	Hydro-chemical and Environmental Investigation of the Addis Ababa Region, Ethiopia	2002	Berhanu G. (Ludwig Maximillans-University of Munich, Germany).
5	Surface and groundwater pollution problems in the Upper Awash River Basin, Ethiopia. MSc-Geology.	1999	Adane B. (University of Turku, Finland).
6	Evaluation of Water Quality and Suggested Improvement Measures: The Case of the Little Akaki River, Addis Ababa, Ethiopia. M.Sc. Thesis.	1999	Agizew N. (Division Of Hydraulic Engineering, The Royal Institute of Technology, Sweden).
7	Sustainable Urban Stormwater Management by Space Management and Subsidiarity Principle: The Case of Addis Ababa, Ethiopia. Phd Dissertation.	2000	Wondimu A (L'Institut National des Sciences Appliquees de Lyon, France). [Original document/French]
8	Survey of Wastewater and Sludge Treatment in Addis Ababa, Ethiopia. M.Sc. Thesis.	1996	Johanson, R. and Kärnhagen, M. (Chalmers University of Technology, Sweden)

VI. WORKSHOPS, EVENTS, ETC.

PUBLICATIONS

	Title	Year	Author
1	Managing solid waste in Addis Ababa. In: Proceedings of the 25th WEDC Conference, J. Pickford (ed). Addis Ababa, pp 32-34.	1999	Beyene, G.
2	Wastewater Management in Addis Ababa. In: Proceedings of the 25th WEDC Conference, J. Pickford (ed). Addis Ababa, pp. 32-34.	1999	Getahun, W and Adinew, A
3	Human interactions and water quality. In: Proceedings of the 1997 AAAS Symposium on Emerging Water Management Issues, Philadelphia.	1998	Zinabu G.
4	Urban Environmental Problems, Planning and Management: The Case of Addis Ababa, Paper Prepared for the Workshop on Urban-Regional Development Planning and Implementation, Awassa.	1996	Yiebeltal G.
5	Industrialization and Development in Developing Countries. Paper Presented for the Seminar on Industry and Environment. Addis Ababa.	1991	Kemal Z.
6	Urban Development and Its Impact on the Environment. In: Ethiopia's experience on conservation Strategy. Volume 3, Addis Ababa.	1990	Techeste A.

APPENDIX 10a: STANDARDS FOR DISCHARGES TO WATER BODIES FROM SPECIFIED INDUSTRIAL SECTORS[4].

1. TANNING AND LEATHER FINISHING

Parameter	Limit Value
Temperature	40 °C
Ph	6 – 9
BOD_5 at 20°C	90% removal or 200 mg/l, whichever is less
COD	500 mg/l
Suspended solids	50 mg/l
Total ammonia (as N)	30 mg/l
Total nitrogen (as N)	80% removal or 60 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 10 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at oil trap or interceptors	20 mg/l
Chromium (as total Cr)	2 mg/l
Chromium (as Cr VI)	0.1 mg/l
Chlorides (as Cl)	1000 mg/l
Sulphides (as S)	1 mg/l
Phenols	1 mg/l

2. THE MANUFACTURE AND FINISHING OF TEXTILES

Parameter	Limit Values
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 50 mg/l, whichever is less
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
COD (mg O_2 /l)	80% removal or 150 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 10 mg/l, whichever is less
Suspended solids	30
Total ammonia (as N)	20
Oils, fats & grease	20
Phenols	1
Mercury (as Hg)	0.001
Nickel (as Ni)	2
Cobalt (as Co)	1
Lead (as Pb)	0.5
Antimony (as Sb)	2
Tin (as Sn)	5
Chromium (as Cr VI)	0.1
Chromium (as total Cr)	1
Arsenic (as As)	0.25
Cadmium (as Cd)	1
Zinc (as Zn)	5
Copper (as Cu)	2
Mineral oils (Interceptors)	20
Benzene, toluene & xylene (combined)	1
Mineral oils (Biological Treatment)	5
Organochlorine pesticides (as Cl)	0.03
Mothproofing agents (as Cl)	0.003
Organophosphorus pesticides (as P)	0.003
Adsorbable organic halogen compounds (AOX)	5
Sulphide (as S)	2

[4] **Source:** Draft provisional standards for industrial pollution control in Ethiopia, EPA, 2005

3. PRODUCTION AND PROCESSING OF IRON AND STEEL

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
Suspended solids	20 mg/l
Mineral oils	20 mg/l
Cadmium (as Cd)	1 mg/l
Mercury (as Hg)	0.01 mg/l
Lead (as Pb)	0.5 mg/l
Zinc (as Zn)	5 mg/l
Chromium (as Cr VI)	0.1 mg/l
Chromium (as total Cr)	1 mg/l
Nickel (as Ni)	2 mg/l

4. METAL WORKING, PLATING AND FINISHING

Parameter	Limit Value
Temperature	40 °C
pH	5.5 – 9.5
Suspended Solids	25 mg/l
Mineral Oil	20 mg/l
Fluoride (as F)	50 mg/l
Phosphorus (as P)	10 mg/l
Arsenic (as As)	0.2 mg/l
Cadmium (as Cd)	0.5 mg/l
Cyanide (as free CN)	0.5 mg/l
Chromium (as Cr VI)	0.1 mg/l
Chromium (as total Cr)	1 mg/l
Copper (as Cu)	2 mg/l
Lead (as Pb)	0.5 mg/l
Mercury (as Hg)	0.01 mg/l
Nickel (as Ni)	1 mg/l
Silver (as Ag)	1 mg/l
Zinc (as Zn)	1 mg/l
Total Metals	15 mg/l
Trichloroethane	0.1 mg/l
Trichloroethylene	0.1 mg/l

5. BASE METAL AND IRON ORE MINING

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	25 mg/l
COD	150 mg/l
Suspended solids	50 mg/l
Mineral oils	20 mg/l
Cadmium (as Cd)	0.5 mg/l
Mercury (as Hg)	0.01 mg/l
Arsenic (as As)	0.25 mg/l
Cyanide (as CN)	1 mg/l
Iron (as Fe)	5 mg/l
Lead (ad Pb)	0.5 mg/l
Zinc (as Zn)	3 mg/l
Copper (as Cu)	2 mg/l
Nickel (as Ni)	2 mg/l
Chromium (as Cr VI)	0.1 mg/l
Chromium (as total Cr)	1 mg/l
Total metals	15 mg/l

6. MALTING, BREWING, DISTILING, PRODUCTION OF WINES AND OTHER ALCOHOLIC LIQUOURS

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 60 mg/l, whichever is less
COD	90% removal or 250 mg/l, whichever is less
Suspended solids	50 mg/l
Total ammonia (as N)	20 mg/l
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 5 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at the oil trap or interceptor	20mg/l

7. MANUFACTURE OF DAIRY PRODUCTS

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 60 mg/l, whichever is less
COD	90% removal or 250 mg/l, whichever is less
Suspended solids	50 mg/l
Total ammonia (as N)	15 mg/l
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 5 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at the oil trap or interceptor	20 mg/l

8. FRUIT AND VEGETABLE PROCESSING

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 60 mg/l, whichever is less
COD	90% removal or 250 mg/l, whichever is less
Suspended solids	50 mg/l
Total ammonia (as N)	20 mg/l
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 5 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at the oil trap or interceptor	20mg/l

9. FRUIT AND VEGETABLE PROCESSING

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 60 mg/l, whichever is less
COD	90% removal or 250 mg/l, whichever is less
Suspended solids	50 mg/l
Total ammonia (as N)	20 mg/l
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 5 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at the oil trap or interceptor	20mg/l

10. MANFACTURE OF SUGAR

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 60 mg/l, whichever is less
COD	90% removal or 250 mg/l, whichever is less
Suspended solids	50 mg/l
Total ammonia (as N)	15 mg/l
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 5 mg/l , whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at the oil trap or interceptor	20 mg/l

11. SLAUGHTERING MEAT PROCESSING AND RENDERING

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 80 mg/l, whichever is less
COD	90% removal or 250 mg/l, whichever is less
Suspended Solids	80 mg/l
Total ammonia (as N)	20 mg/l
Total nitrogen (as N)	80% removal or 40 mg/l, whichever is less
Total phosphorus (as P)	80% removal or 5 mg/l, whichever is less
Oils, fats, and grease	15 mg/l
Mineral oils at the oil trap or interceptor	20 mg/l
Total coliform bacteria (number per 100ml)	400 mg/l

12. TIMBER PRESERVATION

Constituent Group or Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
COD	80% removal or 150 mg/l, whichever is less
Suspended solids	100 mg/l
Oils, fats, and grease	10 mg/l
Chromium (as total Cr)	1 mg/l
Chromium (as Cr VI)	0.1 mg/l
Phenols	1 mg/l
Arsenic (as As)	0.5 mg/l
Copper (as Cu)	3 mg/l
Organohalogens	0.1 mg/l
Polycyclic aromatic hydrocarbons (PAH's)	0.05 mg/l
Fluorides	50 mg/l
Pesticides (each)	0.1 mg/l
Pentachlorophenol	0.1 mg/l
Mineral oils at the oil trap or interceptor	20 mg/l

13. MANUFACTURE OF FERTILIZERS

13.1 PHOSPHATE FERTILIZER PLANTS

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
Suspended solids	50 mg/l
Phosphorous (as P)	5 mg/l
Fluorides (as F)	50 mg/l
Cadmium (as Cd)	1 mg/l

13.2. NITROGENOUS FERTILIZERS (AMMONIUM SULPHATE PLANT)

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
Total nitrogen (as N)	150 mg/l
BOD_5 at 20°C	50 mg/l
Suspended solids	50 mg/l
Phosphorous (as P)	10 mg/l
Phenols	1 mg/l
Total heavy metals	1 mg/l

14. PULP AND PAPER

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 50 mg/l, whichever is less
COD	75% removal or 300 mg/l, whichever is less
Total phosphorus (as P)	90% removal or 5 mg/l, whichever is less
Total nitrogen (as N)	90% removal or 30 mg/l, whichever is less
Suspended solids	50 mg/l
Adsorbable organic halogen compounds(AOX)	7.5 mg/l
Oils, fats, and greases	15 mg/l
Mineral oil at the oil trap or interceptors	20 mg/l

15. CEMENT MANUFACTURING

Parameter	Limit Value
pH	6 – 9
BOD_5 at 20°C	25 mg/l
COD	150 mg/l
Total phosphorus (as P)	5 mg/l
Suspended solids	50 mg/l
Mineral oils at the oil trap or interceptor	20 mg/l

16. PERTOCHEMICAL MANUFACTURING

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 50 mg/l, whichever is less
COD	75% removal or 200 mg/l, whichever is less
Total phosphorus (as P)	90% removal or 5 mg/l, whichever is less
Total nitrogen (as N)	90% removal or 30 mg/l, whichever is less
Suspended solids	50 mg/l
Oils, Fats, and Greases	15 mg/l
Chromium (as total Cr)	1 mg/l
Chromium (as Cr VI)	0.1 mg/l
Phenols	1 mg/l
Copper (as Cu)	1 mg/l
Benzene	0.1 mg/l
Vinyl chloride	0.1 mg/l
Sulphide	1 mg/l

17. PESTICIDE MANUFACTURING

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
BOD_5 at 20°C	90% removal or 50 mg/l, whichever is less
COD	75% removal or 200 mg/l, whichever is less
Total phosphorus (as P)	90% removal or 5 mg/l, whichever is less
Total nitrogen (as N)	90% removal or 30 mg/l, whichever is less
Suspended solids	20 mg/l
Oils, fats, and greases	15 mg/l
Chromium (as total Cr)	1 mg/l
Chromium (as Cr VI)	0.1 mg/l
Phenols	1 mg/l
Copper (as Cu)	1 mg/l
Mercury (as Hg)	0.01 mg/l
Active ingredient (each)	0.05 mg/l

18. PESTICIDE FORMULATION

Parameter	Limit Value
Temperature	40 °C
pH	6 – 9
COD	75% removal or 250 mg/l, whichever is less
Total phosphorus (as P)	90% removal or 5 mg/l, whichever is less
Total nitrogen (as N)	90% removal or 30 mg/l, whichever is less
Suspended solids	30 mg/l
Oils, fats, and greases	15 mg/l
AOX	2 mg/l
Organochlorines	0.1 mg/l
Nitroorganics	0.1 mg/l
Pyrethroids	0.1 mg/l
Phenoxy compounds	0.1 mg/l
Active ingredient	0.05 mg/l
Arsenic (as As)	0.2 mg/l
Chromium (as total Cr)	1 mg/l
Chromium (as Cr VI)	0.1 mg/l
Phenols	1mg/l
Copper (as Cu)	2 mg/l
Mercury (as Hg)	0.01 mg/l

19. PHARMACEUTICAL MANUFACTURING

Parameter	Limit Value
Temperature	40 °C
Ph	6 – 9
BOD_5 at 20°C	90% removal or 50 mg/l, whichever is less
COD	75% removal or 250 mg/l, whichever is less
Total phosphorus (as P)	90% removal or 5 mg/l, whichever is less
Total nitrogen (as N)	90% removal or 30 mg/l, whichever is less
Suspended solids	30 mg/l
Oils, fats, and greases	15 mg/l
Absorbable organic halogen compounds (AOX)	2 mg/l
Organochlorines	0.1 mg/l
Active ingredient (each)	0.05 mg/l
Arsenic (as As)	0.2 mg/l
Chromium (as total Cr)	1 mg/l
Chromium (as Cr VI)	0.1 mg/l
Phenols	1 mg/l
Copper (as Cu)	2 mg/l
Mercury (as Hg)	0.01 mg/l

20. PRINTING AND SURFACE COATING

Parameter	Limit Value
Temperature	40 °C
pH	6.5 – 10
BOD_5 at 20°C	90% removal or 50 mg/l, whichever is less
COD	75% removal or 250 mg/l, whichever is less
Total Phosphorus (as P)	90% removal or 5 mg/l, whichever is less
Total Nitrogen (as N)	90% removal or 30 mg/l, whichever is less
Suspended Solids	50 mg/l
Oils, Fats, and Greases	15 mg/l
Cadmium (as Cd)	0.2 mg/l
Chromium (as total Cr)	1 mg/l
Chromium (as Cr VI)	0.1 mg/l
Copper (as Cu)	1 mg/l
Silver (as Ag)	1 mg/l
Zinc (as Zn)	5 mg/l

APPENDIX 10b: GENERAL STANDARDS FOR ALL OTHER INDUSTRIAL EFFLUENTS

Parameter	Emission Limit Value (mg/l)
pH	6 – 9
Temperature	40°C
Biochemical oxygen demand (BOD_5) at 20°C	80
Chemical oxygen demand (COD)	250
Suspended solids (SS)	100
Total dissolved solids (TDS)	3000
Total kjeldahl nitrogen (as N)	80
Total ammonia (as N)	30
Ammonia (as free ammonia)	5
Nitrate (as N)	20
Dissolved phosphorus (as P)	5
Total phosphate (as P)	10
Fats, oils and grease	20
Aluminium (as Al)	0.2
Arsenic (as As)	0.25
Barium (as Ba)	10
Boron (as B)	5
Cadmium (as CD)	1
Chromium (as total Cr)	2
Chromium (as Cr Vi)	0.5
Cobalt (as Co)	1
Copper (as Cu)	2
Cyanide (as CN)	0.5
Iron (as Fe)	10
Lead (as Pb)	0.5
Magnesium (as Mg)	100
Manganese (as Mn)	5
Mercury (as Hg)	0.001
Nickel (as Ni)	3

Selenium (as Se)	1
Silver (as Ag)	1
Tin (as Sn)	5
Zinc (as Zn)	5
Total heavy metals (combined)	15
Calcium (as Ca)	100
Chloride (as Cl)	1000
Chlorine (total residual, as Cl)	1.5
Fluoride (as F)	20
Sulphide (as S)	2
Sulphate (SO4)	1000
1,1,1-Trichloroethane	0.5
1,1,2-Dichloroethyelene	0.2
1,1,2-Trichloroethane	0.06
1,2-Dichloroethane	0.04
1,3-Dichloropropene	0.2
Dichloromethane	0.2
Cis-1,2-dichloroethylene	0.4
Tetrachloroethylene	0.1
Tetrachloromethane	0.02
Tricholoroethylene	0.3
Polychlorinated Biphenyls (PCB's)	0.003
Polycyclic Aromatic Hydrocarbons (as benzene)	0.1
Absorbable Organic Halogen Compounds (AOX)	2
Dioxins	0.002
Benzene	0.2
An-ionic detergents (as MBAS)	15
Pesticides, herbicides, fungicides and insecticides	0.1
Phenolic Compounds (as C_6H_5OH)	1
Formaldehyde	1
Total coliform bacteria (numbers per 100 ml)	400
Alpha emitters	10^{-7} μc/ml
Beta emitters	10^{-6} μc/ml