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Can We Imagine Pollution Free Rivers around Addis Ababa city, Ethiopia? What were the Wrong-Doings? What Action Should be Taken to Correct Them?

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Abstract

Despite the fact that Addis Ababa city, Ethiopia, is in the quest for sustainable development (SD), the rivers, which are found in and around the city, are highly polluted, which in turn have a serious negative ecological and socio-economic impacts. Industrialization, rapid urbanization, population growth, and informal settlements are the main drivers of the city's rivers pollution, which contributed to the generation of a huge volume of industrial and domestic effluents. Other anthropogenic activities such as agricultural activities, unplanned and injudicious disposal of municipals, hospitals and garages wastes, poor sanitation facilities, poor wastewater treatment, and environmental degradation both within the city and in the surrounding countryside also adds to the rivers pollution. All these factors contributed to a vicious cycle of river pollution, environmental degradation, water-borne diseases and poverty. In general, this article outlines the main sources, and discusses the major problems of the rivers pollution, impacts of the problems, and ultimately suggests the possible solution for minimizing them. Furthermore, the paper argues that in order to reduce the sources of water pollution in the Addis Ababa City River, and address some of the impacts on the riverine ecosystem and people, a multi-stakeholders efforts are vital with the vision of enhanced biodiversity, restored riverine ecosystems, improved water quality of Addis Ababa river basins, and healthier environment for the people of the city. There is also a need of debate and further research on the problems in order to find long-lasting solutions.

Keywords: Addis Ababa city rivers; River pollution; Drivers of pollution; Impact of pollution; Sustainable development groundwater

Introduction

Water is one of the most important compound that comprises our largest planet' (earth), and is the fluids of most organisms that are living on earth [1]. It constantly circulates in between atmosphere and earth surfaces, which includes the land, rivers, lakes, ponds and oceans that make up our planet. 70.9% of the earth surfaces are covered by water, and of which about 97% is found in salt water oceans, 2.4% are ice caps, 0.6% are land surface water such as rivers, lakes and ponds, 1.6% water is retained in the ground water, and the remaining 0.001% is found as vapor, clouds and precipitation [1,2]. Africa appears to have abundance water resources including more than 17 big rivers, which covered over 1,700,000 km^2, more than 160 lakes, which covered larger than 27 km^2 catchments, vast wetlands, and limited but widespread. The annual average precipitation of Africa is plentiful, as compared to that of Europe and North America [3].

Water in Africa is mainly uses for agriculture and domestic purpose. However, utilization of water for industry purpose is very low, which is estimated to be only 3.8% of total annual renewable water resources [4]. Our country Ethiopia, has totally 12 river basins with annual runoff volume of 122 billion m^3 of water, and the estimated runoff is equivalent to 2.6-6.5 billion m^3 of ground water potential. Addis Ababa, the capital city of Ethiopia, has a number of rivers, which are the tributary of main/big/tiliku and little/small/tinishu Akaki River [5]. For example, Kebena, Banche Yeketu, Kortame, Bulbula, Lequ Soramba and kotebe and Fincha, rivers are the main tributaries of the Akaki Rivers [6]. Both of the big and small Akaki rivers are the main branches of Akaki river, which are flowing into the southern direction of Aba-Samuel Lakes [7].

The Great Akaki river rises from north-eastern part (Entoto Kidane Miheret Mountain area) of Addis Ababa city and flows into the eastern part of city [6], and finally runs into Aba-Samuel dam after 53 km. However, the Little Akaki river rises from the north-west of Addis Ababa, on the flanks of Wechacha Mountain, and flows through the western part of the city for 40 km before it reaches the reservoir (Aba-Samuel lakes) [8].

In the Awash basin, Legedadi, Gefersa, Dire and Aba Samuel lake, are the main water resources that provide the Addis Ababa city by man-made water reservoirs [9] and except, all reservoirs but Aba-Samuel lakes supply domestic and industrial water [9]. Although Aba-Samuael reservoir was constructed for the purpose of electric generation in the late 1930s, nowadays, this reservoir is polluted due to municipal and industrial effluents [10]. 80% of the Addis Ababa city's water supply is from these three reservoirs, and the remaining 20% is from one well system, with a total volume of 77 million cubic meters (MCM) yr^{-1} or 210,000 m^{-3} day^{-1} [8]. Fresh waters, in and around Addis Ababa city, such as rivers, lakes and ground water are utilized for irrigation, sand mining, industrial consumption [5], electric power generation, making food, recreation purpose, habit for birds, and aquatic animals, drinking and sanitation purpose [11]. Moreover, in southern parts of Addis Ababa city, the same rivers and streams serve for different purposes such as horticulture, drinking water for cattle, and for other domestic activities.

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Main Sources of Pollution of Rivers in and around Addis Ababa City

In most developing countries, including Ethiopia, huge volumes of untreated wastewater is discharged into water bodies from textile, fertilizer, electroplating, batteries, leather and other light and heavy industries [12]. Furthermore, uncontrolled urbanization and inadequate sanitations, which emanate from the increasing human population, contributes to the serious quality degradation of surface water [13].

Urbanization, industrialization, agricultural activity and an increase in human population for the past one half century are the main causes of water quality degradation [1]. In developed countries, waste removal facilities and programs are considered as a main agenda in urban planning, management, policies and urbanization processes. However, on the contrary, although Addis Ababa city is currently is one of the fastest expanding cities in Ethiopia, and covers an area of greater than 500 km^2. Now-a-days, due to lack of waste collection system (both solid and liquid) and disposal of industrial wastewater to the city river, the rivers pollution in and around the city is alarmingly increasing from time to time [14].

Point sources, which include agricultural activities such as storage, handling, mixing and cleaning areas of fertilizers and pesticides, animal feeding operations, municipal and industrial activities (wastewater treatment plants, industrial discharges, landfills, utility stations, motor pools, and fleet maintenance) and non-point sources such as (pesticides, fertilizers and other toxics that may be washed from afield by rain in the river and river, reservoirs, sediment, industrial runoff and erosion associated with building like mining nutrients, and microorganisms are the main causes of contamination of the rivers and other water bodies , which are found in and around Addis Ababa City [15,16]. Volatile organic compounds, which include manufactured and refined toxic substances such as oils, solvents, fuel products and paint, are the most persistent point-source pollutants that affect ground water.

Both natural and anthropogenic activities may be the causes of nonpoint sources of pollution, and may occur in everywhere across the land and ground, and deposited and found spread out throughout large areas, including wetlands, coastal waters, lakes, rivers as well as ground water [6]. Nonpoint sources of pollution s introduce harmful bacteria, nutrients, sediments, chemicals, organic wastes, and metals into surface waters. Because, Addis Ababa city has not sufficient liquid and solid waste management systems, both nonpoint and point sources discharges their effluents directly or indirectly to the city's rivers and river reservoirs. Furthermore, because most of the generated solid wastes within and around the city are disposed into open spaces, these solid wastes have a chance to be washed by runoff during rains, and flows in to rivers and percolated in to ground water [17,18]. For example, out of the 2256 m^3 or 851 tons of solid wastes, which is daily generated from Addis Ababa city [6], 5% is recycled, 5% is composted, 25% is not collected properly and dumped in unauthorized areas such as open spaces, ditches and water bodies, and the remaining 65% of production of solid wastes per day is collected and disposed in to Repi dump site and became a serious threat to the environment (Figure 1) [19]. The main sources of solid waste, which is generated from in and around Addis Ababa city includes: households (76%), institutions, commercial, factories, and hotels (18%), and street sweeps (6%) [20,21]. Liquid wastes are the second main source of river pollution in and around Addis Ababa city, and these l wastes are drained to the side of roads and join small streams and rivers, and ultimately flow to downstream causing water pollution. Because there is a huge amount of household sewages (liquid dung, domestic wastewater, etc.) in the urban areas such as Addis Ababa city, it is not uncommon to expect high waste water pollution in the cities compared to the rural areas of Ethiopia [22]. For example, from Addis Ababa city, 4 million m^3 wastewater is emanated from industries discharge, and 49 million m^3 from toilets, kitchens, barns and other domestic area [6] ditches and water bodies, and the remaining 65% of production of solid wastes per day is collected and disposed in to Repi dump site and became a serious threat to the environment [6]. The main sources of solid waste, which is generated from in and around Addis Ababa city includes: households (76%), institutions, commercial, factories, and hotels (18%), and street sweeps (6%) [20]. Liquid wastes are the second main source of river pollution in and around Addis Ababa city, and these l wastes are drained to the side of roads and join small streams and rivers, and ultimately flow to downstream causing water pollution. Because there is a huge amount of household sewages (liquid dung, domestic wastewater, etc.) in the urban areas such as Addis Ababa city, it is not uncommon to expect high waste water pollution in the cities compared to the rural areas of Ethiopia [22]. For example, from Addis Ababa city, 4 million m^3 wastewater is emanated from industries discharge, and 49 million m^3 from toilets, kitchens, barns and other domestic area [6].

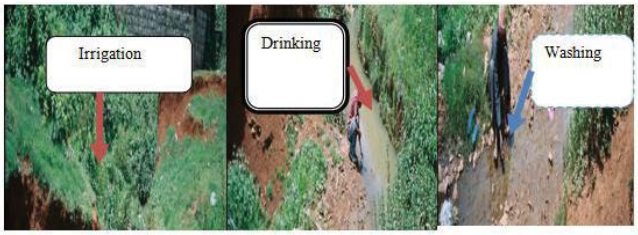

Figure 1: Vegetable farm, swimming and washing in Akaki River [19].

The pollution of rivers, streams, rivers reservoirs and shallow ground waters water quality is alarmingly increasing from time to time, and causing various diseases due to improper deposal of households, municipal, medical/clinical commercial, fuel stations' garbage, industrial and agricultural wastes to open spaces of the city. However, although these wastes are basically polluting and contaminating the above mentioned water resources, the sediments in downstream of the rivers are used by the residents for growing of different vegetables. The major reasons for pollution/contamination of the rivers in and around Addis Ababa city are the following.

Residential (domestic or house hold)

Domestic or household wastes, which are generated from day to day practices, are the major source of water pollution in Addis Ababa city [5,18, 22]. Because 40 to 60% of the rural people of Ethiopia are estimated to migrate to urban areas, the population of Addis Ababa city is alarmingly increasing from time to time compared to other cities of Ethiopia, and this in turn has contributed to an increase in residential/domestic waste. Because the huge amount solid wastes (such as organic wastes, plastics and papers), which are generated from domestic activities of the city, have not well organized management facilities, these wastes are usually dumped to open grounds, stream banks, near bridges and near to residential, and ultimately washed off into rivers [23]. Liquid wastes from different drainages line, domestic liquid waste from over flowing [24,25] and seeping pit latrines, septic tanks, public and communal toilets, open ground excreta defection and gray water from Kitchens and bathrooms flow through different drainage lines discharges into all Addis Ababa River, especially Akaki River (big and small) [25]. Because of inadequate management, domestic wastes from

bathrooms and kitchens, which are produced in Addis Ababa per day is approximately equivalent to 100,000 m^3 [6,18]. For example, 30% of the populations in the city have not access to sanitation facilities, 57% have ventilated and improved pit latrine, 12% have an access to flush toilet and only 4.5% of the population have an access to flush toilet [26,27]. Those residences of the city, which have no toilet facility usually defect in any open spaces, especially at the riverbanks [28]. Because majority of residential houses, governmental and non-governmental institutions, commerce's and industries of the city have directly linked their liquid waste systems, latrines and septic tanks to the main Addis Ababa city rivers without any treatment plant, the city's rivers are lacking aquatic species both benthic macro invertebrate and plant species [29].

Treatment plant sites

In developed countries, most of the worst sources of pathogens in inland surface waters are reduced or eliminated by sewage treatment plants and other pollution control techniques. On contrary, in developing countries' cities such as Addis Ababa, where most of the industrial and their little treatment plant is constructed near to rivers, the problem of pollution is too severe [11]. Rapid urbanization, Poor sanitation situation, uncontrolled waste disposal, and unplanned sites of treatment plants of large and medium scale industries are the major threats of Addis Ababa rivers water quality [30-32], 40% of the large and medium scale industries of the city are manufactured near to rivers, however, currently, nearly all industries, which are operating in the city do not implement any pollution abatement activities i.e. Except very few industries, majority of them discharge their wastes into nearby water bodies and open lands, without/little form of treatments to different industrial wastes. Almost all rivers in Addis Ababa city are contaminated with heavy metals and other pollutants (Table 1).

As showed in Table 2, most of the industrial effluents are discharges their organic, inorganic and liquid waste pollutants into both Great and Little Akaki Rivers ,which finally enters to Abba Samuel Lake. The volume of waste water discharged into Akaki rivers estimated to be 4,877,371 m^3/year (Table 2) [33,34].

Medical wastes or clinical source

Clinical wastes are also contributing to the water pollution of the rivers, which are found in and around Addis Ababa city. 10%-25% of wastes are generated from medical center, and the remaining 75%-90% of the total wastes are generated from non-clinical wastes. For example, in Addis Ababa city, there are 29 different hospitals which are generating 430.7 tons of contagious wastes [34]. Infectious wastes such as human feces, laboratory cultures, tissues and wound clothing, and pathological wastes such as placenta, body parts, bloods and human fetuses are the major wastes of these hospitals. Because most of the hospitals do not have on-site waste treatment facilities, they discharge their wastes directly or indirectly into the streams that are tributaries of big and little Akaki Rivers, which ultimately flows into Aba Samuel Lake [34].

No	Name of Industries	Major heavy metals and other chemical pollutants
1	Food and beverages	Food preservatives, NaOH
2	Textile and leather products	Wastewater from tannery, chrome and sulphides,
		Solid wastes form deharing, fleshing, NaOH, peroxides, aluminum compounds
3	Wood and wood products	Saw dust/wood preservatives, paints, varnishes
4	Paper, paper products and printing	Trimmed papers and inorganic chemicals wastes
5	Non-metallic mineral products	Dust and particulates
6	Machinery and equipment	Inorganic wastewater, scrap metals

Table 1: Major pollutants, which are generated from different factories, in and around the Addis Ababa Rivers [17,39].

No	Types of factories	Quantity of waste water (m^3/year)
1	Iron and steel	146,239
2	Non-ferrous metals	2,217
3	Food and beverages	1,795,252
4	Petrochemicals	11,421
5	Paper and printing	45,967
6	Rubber	205,746
7	Pharmaceuticals	50,089
8	Soups and detergents	1,089
9	Tobacco	31,080
10	Textiles	1,992,597
11	Leather and Footwear	547,860
12	wood	47,805
	Total	4,877,371

Table 2: Volume of wastewater discharged from different factories in Addis Ababa [17,27].

Trends of Addis Ababa City River Pollution

Big Akaki river

Big Akaki river raises from north-eastern parts of Addis Ababa city and flows into Aba Samuel dam. However, due to some industries such as Kaliti Food SC, Akrem Metena Animal Feed Factory, and K.K Textile Factory, it is polluted biologically, chemically and physically [14]. Although this river is basically important for domestic, industrial, commercial and agricultural activities, the peoples, who live in the downstream, are extremely in danger, and their livelihood is also at risk, due to the growing water pollution of the river. They are also using the polluted sediments, soils and wastewater of the big Akaki river to produce vegetables [35]. Moreover, due to the water pollution of the Big Akaki river by toxic chemicals that are generated from different industries, the big fishes, which were living in the river, are almost in extinction [35]. Therefore, in order to improve the water quality of the river, and use it for irrigation, swimming purpose, and aquatic ecosystems, some major parameters of the water quality such as heavy metals, different ions, and fecal coliform need major treatment practices [19].

Little Akaki river

Little Akaki River is originate from North Western parts of Addis Ababa and flowing towards the south, and converging at the Aba-Samuel Dam [36,37]. Big Akaki river catchment area are lesser industrialized than the Little Akaki river, and because of this main reason, Little Akaki river has greenish-dark color, sediment and bad odor, which are associated with industrial and household waste discharges to the river. Moreover, because most industries such as tanneries, breweries, wineries, distilleries, pharmaceutical and national alcohol liquor factories are constructed nearby this river, there is a great chance of releasing untreated wastewater directly into the river [36]. As of the big river, the populations who are living in the downstream of the Little Akaki river, they are cultivating vegetables using the wastewater of the river for their livelihood [35]. However, Compared to the water quality standard level of WHO (World Health Organization), European

Community and the Ethiopian Standards of drinking water, irrigation and other uses Little Akaki river exceed of toxic trace elements, and this leads to river further degraded in water quality of the river.

Kebena river

Kebena River is one of the main tributary of Awash River basin, and it is located at the northern part of Addis Ababa. Despite the livelihood of the community, who are residing around Kebena River, depends on this river as a source of water for various purposes such as for drinking water, bathing, washing house items, sanitation, irrigation, and livestock production [38], the river is continually exposed to contamination by solid and liquid wastes from various sources [36]. The upper stream parts of Kebena River had less values of water quality parameters such as (COD), Chlorine (Cl), Manganese (Mn), pH, Silcon Dioxide (SiO_2), Sodium (Na), potassium (K) and Bicarbonate (HCO_3), however, the downstream parts of Kebena river had high values of water quality parameters such as Sulphate (SO_4^-), Nitrate (NO_3) and Arsenic (As) [37]. The physical and chemical values of water quality parameters of Kebena river is almost the least of all water quality parameters of the big and little Akaki rivers [38]. Furthermore, compared to the little and big Akakai rivers, Kebena river has more organic pollution from commercial, agricultural and institutional wastes and residential pollutant sources (Figure 2 and Table 1) [39].

Welgamo river

Welgamo River rises from the north east high lands of Addis Ababa, and flow to the downstream of Yeka sub-city, and ultimately enters into Akaki Rivers. Residential house practices such as drinking, washing, swimming and irrigation are the main sources for the pollution of Welgamo River [15]. The people, who lived around Welgamo River, is directly discharge their liquid from toilets and solid waste from their houses in to the river (Figures 1 and 2). According to Berihun et al. (Figures 3 and 4) [15], the water quality parameters of values of welgamo river in the downstream area are 6.84, 313 µS to 561 µS, 156 mg/L to 282 mg/L (during dry season), 1.2 mg/L, 7 mg/L to 72 mg/L (during rainy season), and 60 mg/L (due to human and animal urine), for pH, electrical conductivity (EC). Total dissolved solids (TDS), phosphate,

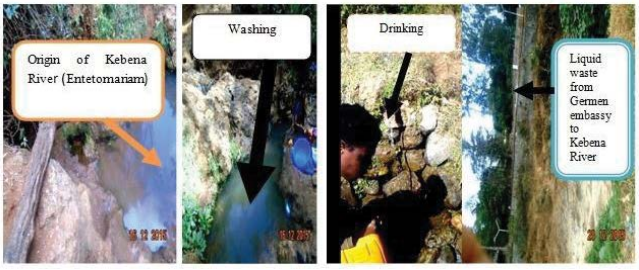

Figure 2: Origin of Kebena river, local community using Kebena river, and waste discharges from different industries.

Figure 3: Liquid waste discharges from toilets into Welgamo river [15].

Figure 4: Solid waste from residents houses, which is dumped into Welgamo river [15].

Biological Oxygen Demand (DOD), and concentration of Chloride, respectively. The study also revealed that due to anthropogenic activity, Welgamo river is highly polluted and unsafe for domestic use.

Kolfe Keranio river

Kolfe Keranio river is located at the west parts of Addis Ababa, and there are more than 50 industries in and around this river, which are discharging their solid and liquid wastes into this river [14]. For example, Gulelle Soap Factory and Addis Ababa Tannery were identified for having industrial waste disposal problems, and discharge their wastes directly or indirectly into this river [24]. The alarming increments in the concentration of heavy metals coliform, and pathogens in and around the Kolfe Keranio river affected irrigation water quality and farming practices in the upstream and downstream of the river.

Bulbula river

Bulbula River is one of the biggest rivers in Addis Ababa city, which has many tributary rivers, and flows through the inner section of the city; however it receives high amounts of liquid and solid wastes from various sources. The river can hold (300-400 mg L^{-1}) all types of wastes, which are originated from household, construction, garages, fuel station and hospitals [40]. Daily domestic wastes, industrial discharges, and wastes from Ethiopian Metal Tools Factory are the main sources of Bulbula river pollution. As Workalemaw reported, Bulbula river is basically important to irrigate vegetables farms, however, vegetables grown in areas, which are close to the Bulbula river, are highly exposed to pollution. For example, as Itanna showed in his study, the soils around Bulbula River exhibited 74.13 mg/kg and 2985.50 mg/kg of Ni and Zn, respectively. However, these values are above the recommended and permissible level, which is 50 mg/kg and 300 mg/kg for Ni and Zn, respectively. Tilahun also reported that although the middle and lower zones of the Bulbula River are highly polluted than the upper zone of the river, it is so highly polluted with some excessive nutrients and trace metals, which are hazardous to natural ecosystem and human health.

Fincha river

Fincha River is located in Yerer, Bole Sub-city, and it is one of the tributaries of Kotebe River. However, the water quality of this river is highly polluted due to various anthropogenic activities and/or unwise land uses such as residence, mixed uses, commerce, social services, open spaces, and small scale industries around the river. These anthropogenic activities contribute to the pollution of this river through discharging and dumping their untreated liquid and solid wastes directly into Finacha river. Furthermore, due to the growing problems of constructing household toilets along the side

of Kebena river, the pollution of this river is increasing from time to time (Figure 5).

Aba-Samuel lake/reservoir

Aba-Samuel lake reservoir is located at south west of Addis Ababa city and it covers an area of 11,454 km^2 [37]. Both Big and Little Akaki Rivers, and their tributaries are discharging (after 53 km flow) into the Aba-Samuael reservoir [38-40], and unfortunately these rivers and their tributaries are serving as a natural sewer line for domestic, agricultural chemicals and industrial wastes [39]. Both Akaki Rivers and small tributaries, which are not directly drain or link with Big and Little Akaki Rivers, are flowing and entering into Aba-Samuel artificial reservoir with their pollutant loads [38]. Because majority of the people, who are living around the Aba-Samuael Lake, use the water of the lake for their daily domestic purposes, it contributed to the pollution of the lake. From the total households, which are resident around Aba-Samuel dam, 70% of them are using the water of the reservoir for bathing/washing and about 93% of their animals depend on the lake. Moreover 40% of the lake and river water are in use for drinking/cooking purpose. Furthermore, the perception study regarding the community health problems, shows that 31.5%, 60.3%, 4.8% and 3.4% of the health problems of the society, who are living around the reservoir, are due to water pollution, water hyacinth related cases, sanitary problems and other cases, respectively (Figure 6).

Figure 5: Dumped solid waste and its pollution in Finicha river.

Figure 6: Eutrophication and pollution of Aba-Samuel lake, and (B) Water hyacinth and its effects on Ababa Samuel lake Sources (A) [9].

Impacts of River Pollution

The Metropolitan city of Addis Ababa has more than 65% of industries [27]. However, majority of the industries, which are found in Addis Ababa, have their own significant negative and positive impacts on environmental, human and animal health, and economical aspects. Improper damping of wastes from household and odor of sewage are the common visible problems in most road side drains of the city. Due to these major environmental health problems, majority of the rivers and reservoirs along the main industrial zones of the city are excessively polluted, which in turn became the main causes of water borne diseases, reduce the quality of life, and underestimate the attractiveness of the city to foreign investors and the competitiveness of the tourism industry [23].

Biological pollutants and their effects on human health

Biological pollutants such as microorganisms can cause diseases such as hepatitis A or E, dysentery, typhoid fever, cholera and diarrhea and these diseases may arise when the people, who live around the rivers, use contaminated river water for domestic purpose or other related facilities. For example, diarrhea and viral hepatitis, in which both associated with fecal pollution, have been the leading infectious diseases in Addis Ababa city. It is also noted that diarrhea alone is responsible for 212,809 outpatient cases throughout the country, and typhoid fever to be the cause of 14,913 outpatients in Addis Ababa [6].

Heavy metals in vegetables

Some vegetables such as potatoes have toxic elements like zinc, nickel, mercury, copper, cadmium and chromium, as does red beet and onions containing chromium which were planted around 390 hectares of land near to Akaki river [6]. The peoples who were lived around Akaki River and in Addis Ababa city were intake carrot vegetables which have high arsenic cadmium and lettuce have high chromium, Swiss chard vegetables have high iron and zinc cabbage have high concentration of lead [22]. These vegetables were risks to human health as shown in Table 3. As Mulu and Ayenew [13] reported that most peoples who lived around Akaki Kality industrial zone were affected by cough, diarrhea, typhoid and typhus due to serous pollution of the nearby Akaki River and in taking of contaminated vegetables that have high concentration of heavy metals (Table 4).

Environmental impacts

The main pollutants of fresh water of Addis Ababa city are synthetic chemicals, used plastics, nutrients load, pathogens, organic compound and other toxic elements like chromium from tannery industries [35]. The fresh water pollutants have significant negative impacts on the macro invertebrate abundance, birds in and around the river and fishes [30]. Heavy metals such as Hg, As, Pb, Sb, Ni, Sr and Cd are a serious cause of ecological problems, and they may be toxic even at low level of concentration especially for surface water ,and ultimately for human being. Despite the fact that all living organisms are composed

Elements	Potential health problem
Arsenic	Gastrointestinal, skin and nerve damage, cancer
Cadmium	Gastroinestinal, kidney and lung damage
Chromium	Lung and skin damage, cancer
Lead	and immune system and kidney damage embryo/feto toxic
Mercury	Brain and kidney damage, embryo/feto toxic
Nickel	Ling, brain, kidney, liver, spleen and skin damage, cancer

Table 3: Selected heavy metal of potential health effects.

Health problems	Percentage (%)
Cough	76.5
Diarrhea	58.8
Typhoid	51
Typhus	45.1
Skin problem	41.2
Gastro intestinal	39.2
Asthma	33.3
Eye problem	29.4
Bronchitis	3.9

Table 4: Peculiar disease occurrence around Akaki Kality industrial zone.

of breaking down useful essential micronutrients such as Cu, Fe, Mn and Zn, and these elements can be detrimental to their physiology at higher concentrations [41]. Anthropogenic activities such as industrial and domestic wastes, surface runoff, landfill leachate, mining, of coal and ore and agricultural activities are the main sources of these heavy metals [42].

The other basic problem of environmental pollution of Addis Ababa city river, especially Aba-Samuel dam, is eutrophication [37], and this problem is occurring due to excessive loads of nutrients such as phosphorous and nitrogen from agriculture, sewerage, pit latrines and municipal wastes effluents into the river [37]. The growing problem of eutrophication in this river may lead to the depletion of oxygen from water bodies due to algal and other water plants growth, which intern can affect aquatic the fauna and flora of the river. 48% of the Aba Samuel Lake is covered with water hyacinth weed, and this contributed to the pollution of the Akaki River.

Social impacts

As Mohammed and Elias [19] suggested, inadequate collection and transport of household wastes (liquid waste, wood, scrap metals and discarded food) and industrial wastes are main factors that effect of the well-being and health of society. Because people, who are living around the rivers, are using the polluted river water, they are affected by several health problems [19]. Through food web system, organic, inorganic and other heavy metals in river water is accumulate and biomagnifies to water species like fishes, soil, sediment and vegetables, and can be major threats to living organisms. Moreover because majority of the people, who are residing around the river, are depending on the rivers for water source (Addis Ababa city, 2012), they are using vegetables, which are grown from highly polluted soils [19].

Economic impacts

Yohannes and Elias [6] reviewed that the two important faces of polluted water, regarding to economic costs, are:

1. To minimize the total amount of water supply facility for household consumption, agricultural activity and industrial usage. This might be direct economic losses of water.

2. Production of any services from unclean water is minimizing in both quality and quantity of services, and this is the indirect economic losses of polluted water. Further to these, the body weight and physical appearance of domestic animals will be decreased, and they will have poor health conditions due to drinking polluted river water. This might has an indirect impact on price and animal reproduction performance [11]. In Africa, due to lack of liquid and solid waste management system, most domestic products loss their economic value, which is equivalent to 5%. However, in spite of all these facts, the economic impacts of Addis Ababa Rivers were not studied, reported and well documented. As Gebretsadik [5] study revealed, most people who are living around the Akaki river, are willing to pay for river protection, and there by mitigate the urban water pollution. Although currently there are efforts to control and treat the river pollution in and around Addis Ababa by the city administration and private sectors, including the recent huge river and riverside development project, all these efforts are very limited and not enough to address the whole pollution problems within the city.

Roles of Institutions in Mitigating the Pollution of the Rivers, which are Found in and around Addis Ababa, Ethiopia

Addis Ababa environmental protection authority (AAEPA)

In Addis Ababa city administration, Environmental Protection Authority is a mandated regulatory body on all systems of waste management, and it formulated and organized a wonderful polices, guidelines and standards, which enable to control the pollution of Addis Ababa Rivers and river side's. This organization has a research division, which are focusing on environmental pollution. Accordingly, many researchers are involved on studies, which are focusing on the pollution status of the rivers such as Akakai River, and the amount of effluents that are discharging directly to the rivers. Furthermore, Addis Ababa Environmental Protection Authority (AAEPA) has also a powerful division, which is called Environmental Pollution Inspection (old name) or Environmental Law and Monitoring (new name), and it follows and controls the pollutant status of industries and their products with the set of policies, rules and standards. When industries are not in line with polices of waste management system, AAEPA is mandated to warn, penalize, and close the industries. However, usually most industries within and around Addis Ababa city are not abide to the existing rules and policies of waste management, and they discharge their waste to the nearby rivers without any treatments [43,44]. In line with this, mentioned that, AAEPA focuses on the awareness creation and working together with the industries and other stakeholders in order to improve their production and waste management system. Furthermore, experts on environmental law and monitoring in AAEPA explained their worries that are very challenging to take measures on polluters because it is difficult to identify the source of pollution [45-47].

Addis Ababa water and sewerage authority (AAWSA)

Addis Ababa Water and Sewerage Authority (AAWSA) is one of the institutions, which control and manage the liquid and solid wastes from households and different industries within and the suburbs of Addis Ababa city administration. The main duties of this organization are to provide services on liquid waste collection with private operators, which provides septic tank empting services. Thus, the, liquid waste of Addis Ababa city is basically controlled by AAWSA, and according to AAWSA report, the organization treats less than 10% of the city's liquid waste, and the remaining pit latrines are disposing their wastewater into the storm water drainage network of the city. Pit latrines uses a combination of centralized and decentralized waste treatments, however, the handling of wastewater treatment residuals and other byproducts of industrial processes are treated through centralized waste water treatment system. Moreover, AAWSA already uses oxidation tank but it takes more space in order to start advanced membrane technology, as it is experienced in nine condominium houses in the city. Thus, conventional treatment

method is implemented to treat the city's wastes, which includes physical, biological and chemical treatments [48,49].

If the management systems of the solid wastes within the city are not addressed in an organized and planned way, majority of the residents within the city will use other options of decentralized waste management system. For example, although majority of the residents of the city uses on-site sanitation facilities rather than off-site facilities, majority of the peoples uses their storm water drains and open fields of court yard for disposing and managing wastes [50]. However, in order to deliver a centralized waste management system to the city, it requires the coordination and commitments of the administrators of the city as well as the integration of the Addis Ababa city and its suburbs urban planning, In spite of the fact that the city is under this situations, it has three centralized systems with different capacity i.e., Kality treatment plant (7,600 m^3/day) currently work above its capacity, which is about 10, 000 m^3/day), Akaki treatment plant (12,500 m^3/day), and Eastern treatment plant (80,000 m^3/day (only plan). Currently, all the treatment plants are functional but Eastern treatment plant, which is also serving as stabilizing pond and receives sludge from vacuum tracks that empty septic tanks.

Addis Ababa city solid waste recycling and disposal project office

The city's administration generally pays attentions to the collection, management services of municipal waste [51]. The main solid waste management system of Addis Ababa city is open damping, which is very poor management system. The city has one open dumping area (traditionally call 'Koshe'), which was established in 1950s, and located 13 km away from Addis Ababa. Due to the expansion of the city, 'Koshe' is currently in the center of city, and still surrounded by many residences and institutions of the city. Surprisingly still now the site serves in the form of open damping system, which affects the surrounding environment [52]. However, considering these problems, the city's administration has built a new sanitary landfill facility at Sendafa, Oromia Regional State, Ethiopia, though it is not still operational due to various reasons [21]. When it became fully functional, this new landfill is expected to process solid wastes for the coming 30 years generated from the City, and it is expected to contribute the solid waste management of the city.

Addis Ababa city river, rivers development and climate change

Adaptation project office: Addis Ababa City Rivers and rivers sides are seriously polluted by liquid and solid wastes, which are generated from households, service giving institution and city industries, and it adversely affected the overall environment and communities of the city [19]. In order to protect and manage the City's rivers, the Rivers Development and Climate Change Adaptation Project has been established with the regulation no 75/2016 by the cabinets of Addis Ababa ministration. The main aim of this organization is to clean, design and develop rivers and riversides for green facilities, and enable the rivers and riversides as a sources of income generation and to clean rivers and riversides, which offer a spiritual, social, economic, educational, and environmental services. In order to carry out all these tasks, the office works in collaboration with Addis Ababa city beautification and park development bureau.

Addis Ababa water supply and sanitation project (AAWSSP)

Addis Ababa city water supply and sanitation project office has adopted a city water resources management policy, a water supply and sanitation strategy, and a water sector development program. In line with its economic development, the water supply service level also needs to be improved to its maximum potential and to the expectation of the country's economic development. The development trend then would be climbing a step up in the water supply service level ladder at each economic development level of the country and ensuring each time universal access at that level. So, this organization is basically focused on controlling system of liquid and solid waste and availability of water the city and sanitation of the city. Moreover, the office has also mandate increasing the city water supply. Because, the main sources of supplied water is underground water. When the city river is polluted by wastes from household and different industries, underground water is also affected by the impacts of river due to toxic and hazardous substance percolated and leachate in to ground. So, in order to safe underground water for drinking purpose, this organization must be control open defecation of solid and liquid and wastes along river side.

Institutional coordination

Coordination is about synchronizing relationships and it is vital for reducing point and non-point sources. The coordination and partnership of city increases efficiency, facilitates the possibility of sharing risks and benefits, and creates enabling condition to evaluate the condition of City Rivers. Coordinating and collaborating activities regarding to river pollution with different relevant agencies at all levels will help to promote synergy and assure effective delivery. Coordination with and among stakeholders, allow for articulation of country Priorities, avoid duplication of efforts and unnecessary overburdening of activities.

Environmental policy of Ethiopia

The Environmental Policy of Ethiopia was approved by the Council of Ministers of the FDRE on April 2, 1997. The goal of this policy is to improve and enhance the health and life quality of all the people in the country and to promote sustainable social and economic development, without compromising the ability of the future generations to meet their own needs. The policy contains provisions to prevent industrial pollution. The key provisions, among others are, the operating industries should minimize or prevent discharges of substances, biological materials from industrial plants. It also adopts the polluter pays‖ principle to make the polluting enterprises pay for their pollutants. The policy prohibits all acts causing environmental degradation, environmental pollution or environmental incidents and river water pollution. The policy, in general terms, regulates the responsibilities of industries and requires proper management of waste which affects City Rivers. It also deals with penalty schedule for breaking the law and adopts the Polluter Pays Principal (PPP), whereby the organization responsible for pollution or degradation of the environment must financially compensate for the damage. This financial punishment has a potential to discourage the polluting industries from further pollution if it is properly implemented and proportional to the extent of the pollution.

Environmental pollution control proclamation No. 300/2002

This Proclamation was enacted to help realize the effective implementation of the environmental Objectives and goals incorporated in the Environmental Policy. In addition, the Proclamation was enacted because the need to protect the environment in general and particularly safeguard human health and well-being, preserve the biota in the river and maintain an untainted aesthetics and to prevent or minimize the undesirable pollution resulting from economic development through appropriate measures. The proclamation also grants, EPA and Regional environmental agencies are empowered to take administrative or legal measures against persons that release any pollutant in violation

of laws provided regarding the control of environmental pollution. Moreover, development activities that likely cause pollution or other environmental hazards shall have an obligation to install sound technologies or adopt practices that avoid or minimize the generation of waste and to promote the re-use or recycling of effluents, discharges and wastes in general.

Conclusion

Now-a-day, the rivers, which are found in most part of Ethiopia, including Addis Ababa city, are highly contaminated mainly due to inadequate industrial waste management system, increments of urban human population, expansion of urbanization, and lack of sanitation infrastructure facilities. The water qualities of Addis Ababa city rivers were alarmingly decreasing from time to time, and the main causes for the Addis Ababa river pollutions are wastes from residents along the river and away from the river side, industries, hospitals (point and non-point sources), and macro and mini sectors of city. Among the different city rivers, Big and Little Akaki Rivers are highly polluted by heavy metal accumulation, which is originated from industries around them. However, the residents in the upstream and downstream of these rivers, are using the rivers as a source of water for irrigating their vegetable farms, draining, livestock raring, and other purposes at home. In spite of the fact that vegetables have a power to accumulate large concentration of heavy metals, the vegetable produces from these farms may harm human and animal health system through the system of food chain and food web. Moreover, because of drinking and eating of contaminated water and vegetables, big numbers of the residents of the city are facing health related difficulties, which in turn increase the medical expenses.

All the above mentioned facts indicate that the problem of water quality is posing serious impacts on the environmental, social, and economical aspects of the city, and this problem is highly increasing from time to time, due to very week inspection of the mandated regulatory institutions, low enforcement of environmental policies, lack of institutional capacity, and poor cooperation among the environmental regulatory bodies and other stakeholders. Therefore, it is highly recommended that all stakeholders, including the city administration and the local community, should participate in the formulation of policies, standards, guidelines as well as other activities, which help to mitigate the pollution of the City Rivers.

Recommendation/Suggested Possibility for Minimizing of Water Pollution

The rivers, which are found in and around Addis Ababa city, Ethiopia, is prone to contamination and severe pollution, and the effect of pollution could have a negative impact on the social and economic aspects of residents in the city. As many literatures stated, in order to manage, protect and use the rivers of the city in a wise way, it requires collaborative actions. From the review of different past researches, in order to reverse these severe problems and mitigate the pollutions of the rivers as well as the livelihood of the community, the following recommendations are forwarded.

An intensive awareness should be given to the different communities of the city on the negative effects of pollution, how to defend their rights from such pollution, and how reverse the growing pollution problems.

1. The government as well as the city administrators should enforce the manufacturing industries to treat their wastes, minimize their wastes through utilizing the best available technology and governed by environmental standards, rules and regulation, which are set by the regulatory bodies of the country.
2. It is very important to consider a centralized waste management system for any new construction, and a decentralized waste management system for old constructions or already urbanized areas.
3. In order to ensure the water quality of the rivers and other related sources, it is very important to have affordable waste management strategy for the society, cooperation among stakeholders, ,and continuous follow up and monitoring of the industries by the relevant regulatory bodies.
4. It may be necessary to have a single treatment plant for many sources by minimizing industries dispersion through clustering.
5. Based on polluter pay principles, other alternative water sources such as constructing deep wells and developing existing springs should be considered by the city's and its suburbs administration.

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