

An overview of water pollution status in Ethiopia with a particular emphasis on Akaki River: A Review

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Abstract

Introduction: Today, water pollution problem is heard all over the globe because of the ever increasing population, industrialization, urbanization and other human activities. Ethiopia too is facing the problem of water quality deterioration. At the capital city of the country where the problem of water pollution is at its highest state at present endowed with numerous seasonal and perennial small streams that flow to the little and Great Akaki Rivers.

Objective: To review Akaki river pollution status, major sources water pollution and implication of the pollutants

Methods: The review was organized reputable journals, articles, and review papers were used using searching key phrases “water pollution in Ethiopia with a particular emphasis on Akaki River”.

Results: The reviewed result showed that, sludge and wastewater from Addis Ababa City dwellers and sewer outfalls of pollution have made a significant contribution to the worsening of the Akaki Rivers water quality. The poor sanitation facilities and services of Addis Ababa, as well as lack of proper attention to Akaki Rivers water quality management. At its present situation, the river is not better than an open sewer conveying from weak to medium strength domestic wastewater. The physical, chemical & bacteriological analytical results of the rivers indicate that the river is polluted much beyond the concentration range of the quality specification and the provisional ambient water quality standard developed by the federal EPA and other countries.

Conclusion: Nearly all study results revealed that the rivers’ water does not satisfy the basic standard requirements of water supply for human consumption, domestic purposes, irrigation and animal drinking. Besides these, it was observed during different surveys that the rivers’ water is serving for irrigation, bathing, and human and cattle drinking and all domestic purposes even though it is polluted and unsafe. Because of this water-related human health problems such as diarrhea, dysentery, amoebiasis, ascariasis, and others will be common

Keywords: Ethiopia, Addis Ababa, Akaki River, source of pollution, physical, chemical and bacteriological

Introduction

Freshwater is a scarce resource, essential for agriculture, industry, and human and animal life existence. We depend on our streams and rivers to deliver much of these water uses. Without adequate quantity and quality of freshwater sustainable development will not be true for all countries of our globe (Abera et al. 2015). Ethiopia is a country having great geographic diversity. The topography varies and ranges from high peaks of 4,550m above sea level to a low depression of 110m below sea level. Ethiopia has great potential of both surface and groundwater resources and result in giving a name to the country as the water tower of East Africa (Ademe et al. 2014). Pure water does not exist in nature. Its quality can be affected by some dissolved or suspended substances, and consequently, it becomes polluted. Water pollution is a state of deviation of water purity from the normal condition to the abnormal and the affection of its function and properties. It is the addition of something to water, which changes its natural qualities, so that the riparian owner does not get the

beneficial uses from it. Pollution of water bodies from technological activities such as industrial effluents and agricultural chemicals is considered a minor threat in developing countries like Ethiopia, though urban water pollution is growing at alarmingly faster rates (Abera et al. 2005). The main sources of pollution that enter urban surface water bodies are industries, municipal solid waste and oily wastes from garages and fuel stations (Gebre et al. 2009). Addis Ababa is endowed with numerous seasonal and perennial small streams that flow to the little and Great Akaki Rivers. The streams were clean to a greater or lesser degree in the early days of the establishment of the city. However, the situation has been changed through time, as a consequence of expanding industrialization and extensive population growth.

At the sides of Akaki River that runs through the center of Addis Ababa, there are many industrial establishments among which most of them are discharging their effluents directly to this river without any prior treatment. In connection to the available industries, from the total population which dwells in

the city, about 30% have no toilet facility and the human excreta from direct defecation on every open space including the river banks creates a burden to Akaki Rivers (EPA 2012; Birhanu et al. 2017).

Direct discharge of domestic and municipal sewage to Akaki River, deteriorate the quality water. Due to weak policy and enforcement of laws sewage wastes directly released into the river. The direct discharge of the pollutants to downstream of Akaki River could entail negative effect on the quality of the river, as well as serious harm to the aquatic life and downstream user (Ljiljana et al. 2014). From the increasing human population, uncontrolled urbanization and waste disposal cause serious quality degradation of surface waters. Now a day's water pollution from disposal of industrial wastewater is becoming an environmental concern in Addis Ababa city and its vicinity areas.

Akaki River is one of the victims of water pollutants released from different sources like industry, agriculture, domestic waste, service industry waste, etc. Addis Ababa is endowed with numerous seasonal and perennial small streams that flow to the little and Great Akaki Rivers. The streams were clean to a greater or lesser degree in the early days of the establishment of the city. However, the situation has been changed through time, as a consequence of expanding industrialization and extensive population growth. Akaki River is used by the downstream community for agricultural activities, and among the major source of water for the Addis Ababa population Akaki well is the first one.

Akaki River is one of the tributaries of Awash River which is one of the major rivers used for different purpose in the country, so that the pollution of Akaki River also affects the eco-system services of the Awash River, but there is no organized data which shows the level of pollution, the type of pollutant, the major implication of those pollutants rather unorganized researches are conducted here and there (Shah 2008). The main purpose of this review literature is to come up with a meaning full data which shows the status and level of pollution of Akaki River.

Materials and Methods

This review paper was written using searching key phrases “water pollution in Ethiopia with a particular emphasis on Akaki River”, “water pollution in Ethiopia”, “Factors affecting water pollution ” in springer link, science direct, library genesis, jester, and www.nap.org searching web pages. From these searching, peer reviewed journals and review papers were used. The interpretation of the result of each document was done using bar graphs, lines and scatter plot in a Microsoft excel. In view of the current

demand of this review, the pollution assessment assignment employed a range of tools to gather and analyze data from secondary sources.

Results

Pollution status of Akaki River: The location of Addis Ababa with respect to the water source is described below. The pollution statuses of Akaki River determine the quality of water for the residents of Addis Ababa and the downstream community. In the reviewed papers, studies were carried out by a number of researchers and institutions aiming at learning about the status, cause and effect of water pollution of the two major rivers found in and around Addis Ababa. These rivers, are the little and great Akaki rivers. And all of the studies have forwarded recommendations on how to mitigate the problem. The review also showed that Akaki River in Ethiopia is purported to be contaminated with multiple toxic agents, including metals. The river runs through residential, commercial, and industrial areas of the capital city of Addis Ababa (Ellen et al. 2015). The nature and extent of water pollution are characterized by several physical, chemical and bacteria biological parameters, as part of the present assessment, of water pollution in the little and Great Akaki River. The following three different water quality parameters were chosen and analyzed for their physicochemical properties.

Physical property: Unlike the Great Akaki, the physical appearance of Little Akaki is dark. The black turbidity of the river contributing the dark color to the river is probably a result of the decomposition of organic wastes. During the dry season, the river would be expected to have a persistent objectionable odor. This is because during the dry season there is a shortage of oxygen and the organic materials decompose anaerobically, which give rise to the pungent smell on the surface water. However, during the wet season, wastes in the river basin will be washed away, as a result, the objectionable odor is minimized. One of the physical parameters that was treated in the current study was electrical conductivity ($\mu\text{S}/\text{cm}$). This parameter is playing a role as a proxy of ion content in the river. A high electrical conductivity in the study area is a signal for the most disturbed river system, high ionic presence, and nutrient load. At the more urbanized area of the river basin.

Chemical property: The water quality of the Tinishu Akaki River (TAR) shows pattern of behavior linked to anthropogenic sources with the intensity of human pressure associated with industrial effluent, domestic wastes and agricultural activities (Samuel et al. 2007). The nitrates discharge into Akaki river basin from many sources: from city sewage, defective septic tank effluents, municipal waste, industrial waste, wastes

from livestock and chemical fertilizers containing nitrogen (Birhanu et al. 2017). The most significant parameter related to the sustainability of aquatic life in rivers, Dissolved oxygen (DO) was depleted to a level of 0.1 mg/l in downstream sites. Biochemical oxygen demand (a measure of organic pollution and a cause for oxygen depletion) reached a level of 1250 mg/l, i.e., about 400-folds above the normal level (3 mg/l). Other nutrients (phosphate, nitrate, and ammonia plus ammonium) were also elevated in downstream sites along the pollution load (Ellen Yard et al. 2015).

Major source pollutants of Akaki River: Naturally water bodies can contain limited portions of certain chemicals and these water quality parameters can increase in concentration due to natural processes such as evaporation, transpiration, and deposition. Moreover, external pressures as domestic, municipal and industrial waste effluent, fast population growth and rapid industrialization, and lack of sewage networks and poor living condition have caused the deterioration of surface and groundwater quality in the capital city of Addis Ababa. This eventually could lead to an increase in the concentration of a certain water quality parameters above potential natural levels and even above WHO acceptable levels ((Birhanu et al.2017). The pollution levels where parameter levels go above WHO levels are seen in both Little Akaki River and Great Akaki River and can potentially be attributed to many sources. The major sources of water pollution are likely from industries and municipalities. Moreover, the water pollution from agriculture and natural activities also aggravate the water quality. Major pollutants generated from these industries include solids, organic pollutants such as oil, pesticide, cleaning solvents, detergents and inorganic pollutants

such as nitrates, phosphates, sulfate, chloride, and others. Besides, heavy metals, acids, and alkalis are the most pollutant substances generated from the industries (Ademe et al.) Industrial source of pollution: This is mainly point source pollution because the pollution sources are easily traceable and result from a single pipe or series of pipes. Industrial effluent is concentrated towards the northwestern and southwestern sections of the city. As compared to the Great Akaki River which predominantly passes through residential and commercial areas in the northeastern and southeastern parts of the city, Little Akaki remains to be the primary recipient of most of the industrial effluents discharged within the city. The major exposure of the Great Akaki River to industrial effluents only appears in its lower catchment when it crosses through the largest industrial town, Akaki. Other industries also discharge their effluents into public sewers. This creates economic problems, adds to the sewerage treatment problem, deteriorates sewer structures, increases maintenance cost due to the presence of high amount of sulfates effluents which tend to form sulfuric acid and corrodes the sewers, and finally increases pollution on Akaki River (Birhanu et al. 2017). Leather processing requires a large amount of chemicals like sodium chloride, chromium sulfate, calcium salts, ammonium salts, sodium sulfide, acids, alkalis, fat, liquor, and organic dyes. However, one of the major emerging environmental problems in the tanning industry is the disposal of chromium contaminated sludge produced as a by-product of wastewater treatment. Tannery effluents severely affect the mitotic process and reduce seed germination in extensively cultivated pulse crops (Teklit et al. 2015).

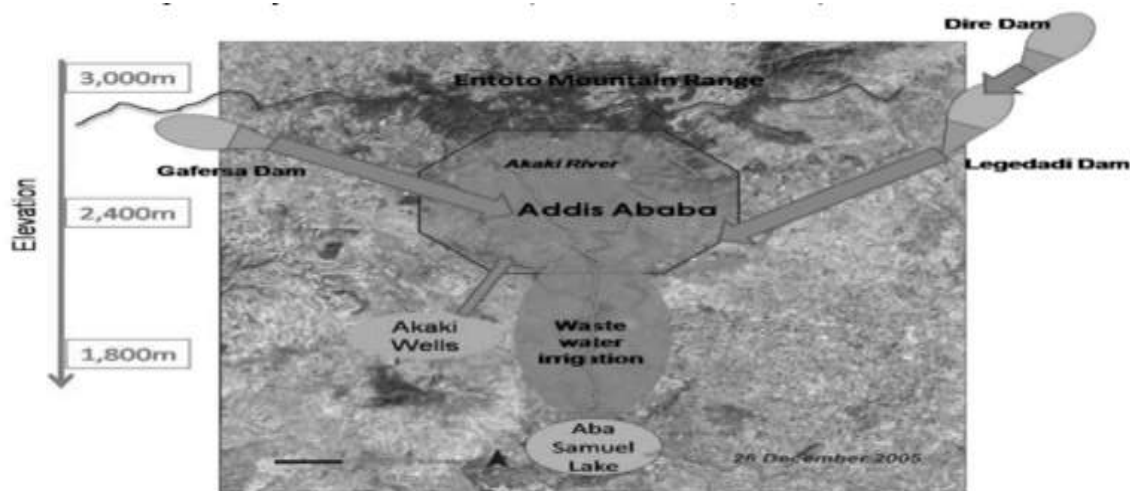


Figure 1: Water links of Addis Ababa with surroundings rural areas (UNDP/CCF-2, 2005)

Table1: Main pollutants generated from industries around Akaki River, Addis Ababa, Ethiopia, 2019

Industrial Sector	Major Pollutants
Food and Beverages	• Food preservatives. • Cleaning chemicals, e.g. (NaOH, detergents). • Air pollution from dust and fuel combustion
Textile, clothing, tanning and leather goods	• Waste water from scouring, mercerizing, bleaching and dying (e.g. NaOH, peroxides, aluminum compounds and dyestuffs) • Wastewater from tannery, chrome, sulphides, ammonium salts. Chlorides etc. • Solid wastes from de haring, fleshing and trimming of hides and skins
Wood & wood products	• Sawdust/wood preservatives, paints, varnishes
Paper, paper products & printing	• Printing chemicals, lead in granule form • Trimmed papers and inorganic chemical wastes
Chemical, rubber & plastic products	• Solid wastes of scorched rubber, scraps of rubber and PVC, plastics, dust • Organic and inorganic chemical wastes
Non-metallic mineral products	• Dust and particulates, air pollution from fuel combustion
Basic iron & steel	• Scrap metal, air pollution from combustion
Machinery & Equipment	• Inorganic waste water, scrap metals

According to the reiview, wastes from over 35 industrial processing plants that enter Akaki River make it the most polluted river in the country. Especially, wastes from the Akaki Textile Factory and the ELICO Tannery comprise the greatest load of pollutants. In this review, a number of studies have indicated that among the industries located in Addis Ababa, 90 percent of them discharge their wastes without any treatment into the nearby water bodies and open spaces (Authority 2005). Among these

industries, Awash Tannery, Ethio-pickling and Tanning, Teramage Edible Oil, Awash Wineries, National Alcohol and Liquor, Addis Ababa Abattoir, East Africa Bottling Ltd., E, thiopia Marble, National Tobacco Enterprise, and Ethiopian Meat Concentrate discharge their wastes to the Little akaki River and Ethiopian Meat Concentrate, St. Gorge Brewery, Addis Ababa Bottle and Glass discharge their wastes to the tributary of Litle Akaki River.

Table 2: Hospital source of pollutionto the Akaki River, Addis Ababa, Ethiopia, 2019

Ser. No	Hospitals Name	Location in the City	Akaki Watershed			
		Western	Central	Eastern	Little Akaki	Great Akaki
1	Black Lion		✓			✓
2	Zewuditu		✓			✓
3	Balcha	✓			✓	
4	Paolos	✓			✓	
5	Amanuel	✓			✓	
6	Petros		✓			✓
7	ALERT	✓			✓	
8	Yekatit		✓			✓
9	Menelik			✓		✓
10	St. Gabriel			✓		✓
11	Ayat			✓		✓
12	Tibebe		✓			✓
13	Betel	✓	✓		✓	
14	Gandi		✓			✓
15	Ras Desta		✓			✓
16	Bete Zata		✓			✓
17	Ethio-Tebib	✓				
18	Zembaba General Hospital		✓			✓
19	MMD Hospital			✓		✓

The infectious waste management system and hygiene practices of the specialized General Federal Hospitals assessment results indicate that all most all of the surveyed hospitals and the observed once have no on-site waste treatment facility and they directly or indirectly dispose wastes into stream courses that are tributaries of either Little or Great Akaki Rivers (Ademe et al. 2014). Thus, the infectious clinical

wastes, chemical residues, and detergents used for cleaning purposes enter the river and result in serious environmental pollution problems that the downstream dwellers are facing (Abebe et al. 2010).

Agricultural source of pollution: Agriculture is also one of the main driving forces for the pollution of Akaki River. Pesticides and fertilizers used for agricultural practices can be major polluting agents for

water bodies. For decades, people living in the periphery of Addis Ababa, along the Akaki rivers bank have been growing different vegetables and cereal crops. According to A report of EPA diverting Little Akaki River for growing horticultural crops mainly starts in the middle catchment of the river around Amanuel Hospital. These horticulture farming activities are extended downstream all along the plots of lands on the riverbank up to the farming fields found behind Kality town. Apart from the horticulture farming practices, quite many farmers grow other crops on close distance along the riverbank Pesticides and fertilizers are widely used by nearly all farmers in the production of crops. Thus, there is a high probability of leaching of pesticide and fertilizer residues and polluting of the Akaki Rivers (Birhanu et al. 2012).

Municipal source of pollution: The pollution from this type is generated from two types of sources i.e. municipal liquid waste and municipal solid waste. The municipal liquid waste consists of sewage, surface runoff, human excreta, and other domestic wastewaters. Domestic sources of pollution include cleaning of clothes and dishes, and human wastes. The number of E. coli and streptococcus faceless bacteria which is present in several of the water bodies sampled

Table 3: Research's conducted on Akaki River, Addis Ababa, Ethiopia

Data sources	Year of analysis	Sample size	Average	99% confident interval of the true mean,	End or reach	River body
Pollution status assessment, EPA, 2002	2002	36	66.58	33.53-99.63	Aba Samuel Dam	Little and Great Akaki
Agizew Niqussie Master of Science Degree, Thesis No. 406, Feb. 1999	1998	30	174.73	105.63-343.83	“	Little Akaki
Tassew Nigussie Heyyi AAU School of Graduate Studies, 2005 Dry season	1997	22	118.59	3.78-233.4	“	“
Tassew Nigussie Heyyi AAU School of Graduate Studies, 2005 wet season	1997	22	32.22	16.08-48.36	“	“

Statistical analysis for the pollution load dependence on catchments and seasons was done for 1997. The result shows that there was no significant difference in the true mean BOD value among the catchments for the wet and dry seasons, and a significant dependence between the seasons and catchments at 99% confidence level for the year. In the same way, the analysis results statistical proofs for the 2002 pollution status assessment also shows a 99% confidence level that: True mean range for BOD value of

- The Upper and middle.....46.56-158.62 mg/l
- The Middle and lower.....37.42-149.5 mg/l, and
- The catchments (upper-lower) 33.53-99.63 mg/l

There was a significant difference observed between the true means BOD of the upper and lower catchments of little and Great Akaki Rivers the true mean BOD of the middle catchments was significantly greater than that of the upper and lower catchments.

here is telling the amount of pollution from human waste. Unlike industrial wastes, the characteristics of domestic sewage are relatively constant. The domestic sewage from one residential area is approximately of the same composition as from any other residential area because of the common habits of the people within the region (Samuel Melakua et al. 2007).

Industrial units located in and on the outskirts of the city, intensive agricultural practices along the riversides and indiscriminate disposal of domestic and municipal wastes are the major sources of Tinishu Akaki River (TAR) water pollution. (Samuel et al. 2004). This loss of aesthetics and associated pollution problems can easily be observed at the biggest recreational park in the city, Behere Tsegue Park.

Mainly the Little Akaki traverses through the middle part of the recreational park. Despite the charm of the park, both sides of the river basin are engulfed by solid waste transported from upstream. Moreover, the wastewater drained to the river from Ethio-pickling and tannery factory inside the park adds to the contradiction between the charm and aesthetic damage caused by waste discharge. The table below shows that some of the research conducted on the Akaki River focused on Biological Oxygen demand.

NB: The statistical proofs result of the year's show that Akaki Rivers water are polluted.

Implication of the Pollutants: Though chemicals have changed our lives for the better, they also create an increasing threat to human beings, animals and the environment. These chemicals include PCBs, Aldrin, Copper, chromium Arsenic, Tetra Chloro-ethylene, and others. Ethiopia, there is a growing concern about the adverse effect of industrial discharge on the environment where soil and water qualities are the main pillar of it. Majority of the people who lived in agriculture are highly affected by this consequence (Mesfin K et al. 2014). In the study conducted on the contaminated sites by EPA and UNIDO, 2005, there are contaminated sites by POPs and other chemicals which can be a threat, to Akaki rivers water quality. PCBs that found in Goffa main store are only 200 meters away from Little Akaki River.

Table 4: Pollution load on great Akaki River (Authority 2005)

Standard(Draft ambient surface water quality standard for Ethiopia)	BOD5 <_5mg/l O2	DO Min 6mg/l O2	NH3 20µg/l	Cl 250mg/l
Sample Location				
Before Gulele Soap Factory	3.5	7.0	0.53	5
Addis-Jimma Road Bridge (Near Building College)	339	0.8	32.3	110
Addis Jimma Road Bridge (Zenebe Work Area)	40	0.6	8.8	50
Fifth Police Station Bridge	535	0	63	83
Abattoir Area	444	0	71	85
Near Behere Tsige Park	252	0	52.5	65
Down Stream of Kaliti waste water treatment plant	105	0	80.6	235
Near Legedadi Dam	5	7.7	0.6	2
End of Bole Runway	32	1.0	21.3	35
Near Akaki Bridge	10	4.7	0.9	22

Table 5: Report on the status of pollution in great and little Akaki Rivers, 2002 (Authority 2005)

Sample No	pH	D.O	B.O.D	NO ₃	SO ₄	Cl	NH ₃	K.N	Conductivity	T.C
Standard →	6-9	Min6mg/lO2	<5mg/lO2	50mg/l	200mg/l	250mg/l	20 µg/l	2mg/lN	1000µs/Cm at 200C	10 MNP WHO
1	8.1	4.8	4.6	4.6	0.4	15.5	0.42	0.43	297	172000
2	11.43	6.7	2.1	2.6	24.6	5.5	2.45	2.49	421	542000
3	8.52	3.9	82	0.3	24.2	27.5	0.25	0.27	550	1609000
4	7.99	0	153	0.6	3.5	27	30.5	31.26	1018	34800000
5	7.98	0	167	0.6	0	39.5	34.75	36.91	1281	54200000
6	7.79	4.9	600	0.6	78.5	157.5	9	9.21	1038	49000
7	7.35	8.5	8	0.4	57.4	105	7.65	8	838	17000
8	7.52	5.1	17	0	56.2	130.5	7.68	7.95	804	46000
8	7.75	5.9	2.4	3.7	83.3	90.5	4.62	4.81	805	1720000
10	7.06	0	109	0	19	177	23.3	24.78	1049	9180000
11	7.61	0	197	0	10.9	156	46.75	47.86	1152	16090000
12	6.93	0	97	0	14.8	181	23.25	23.73	1086	9180000
13	7.52	0	198	0	48.8	198	24.5	26.35	1281	17200000
14	7.95	3.1	152	0	15.3	149	31.25	37.41	189	14100000
15	6.95	0.33	14.25	0.9	6.25	155	43.75	44.15	543	34800000
16	7.12	0	8.1	1	10	110	NR	NR	1125	24000000
17	8.5	7.6	3.6	11.1	1.1	72	9.13	9.17	899	340000
18	7.76	4.2	59	0	7.8	38.5	21.12	21.31	815	1690000
18	7.79	0.9	102	0	12.3	31.5	27	27.87	832	16090000
20	8.07	0.7	165	0	1.3	14.5	25.88	27.03	828	91800000
21	8.03	1.7	147	0	1	17.5	26.63	27.87	799	54200000
22	8.12	3	80	0	0	15.5	28.1	29.36	763	9400000
23	6.65	3.2	14.7	0.3	415	128	20.625	21.034	621	4900000

The same survey pointed out that there is a spillage of PCBs. Furthermore, some 200 tons of copper, chromium and Arsenic chemicals imported for timber treatment have been buried which can be a very serious health hazard. Polluted water bears two kinds of economic costs: firstly, pollution reduces the total amount of adequate water available for household consumption or agricultural and industrial usage. Thus, there are economic costs of water held back from supply. Secondly, there are costs related to the use of polluted water for consumption and production (Gebre et al. 2009).

Aquatic ecosystems are threatened worldwide by pollution, as well as non-sustainable land-use and water-management practices that are reaching critical levels. Biological parameters are increasingly studied as more sensitive indicators of ecosystem integrity than physicochemical parameters (Abebe et al. 2017).

Water pollution may damage aquatic populations such as fish, shrimps, and crabs. Although there are no data available for types and quantity of fish species in the rivers of Addis Ababa, the name "Kurtume " has been found in old literature, which suggests that once there was fish present in the Great Akaki River and its tributaries.

The other concern of water pollution is on the residents live in /or around the polluted water bodies. There is little information in the published literature of what effect, if any, the Akaki River might have on residents living downstream from Addis Ababa, and whether residents living in this area might have increased risk of exposure to metals and other contaminants compared to the general Ethiopian population. It is possible that these residents could use the river water for irrigation, animal husbandry, or other uses (Ellen Yard et al. 2015). According to Ellen Yard et al. 2015,

there is no evidence that exposures were a result of proximity to the Akaki River or of domestic use of the river water. This may be due to participants were not using the Akaki river for domestic uses like cooking, drinking, etc.

Discussion

According to the assessment of different literatures, the Akaki River is highly polluted and some researchers considered it a dead river. The Akaki River in Ethiopia is purported to be contaminated with multiple toxic agents, including metals. The river runs through residential, commercial, and industrial areas of the capital city of Addis Ababa, this leads the river to be polluted in a different form of other rivers.

Due to the decomposition of organic waste, the feature of the water is very dark. Especially during the dry season because of lack of oxygen the river experience objectionable odor. One of the physical parameter that was treated in the current study was electrical conductivity ($\mu\text{S}/\text{cm}$). This parameter is playing a role as a proxy of ion content in the river. A high electrical conductivity in the study area is a signal for the most disturbed river system, high ionic presence, and nutrient load. At the more urbanized area of the river basin. The most significant parameter related to the sustainability of aquatic life in rivers, Dissolved oxygen (DO) was depleted to a level of 0.1 mg/l in downstream sites. Biochemical oxygen demand (a measure of organic pollution and a cause for oxygen depletion) reached a level of 1250 mg/l, i.e., about 400-folds above the normal level (3 mg/l). Other nutrients (phosphate, nitrate and ammonia plus ammonium) were also elevated in downstream sites along the pollution load.

The major source of water pollution for both Little and Great Akaki River are industrial, Hospital, Agricultural and municipal are the major one. The difficulty of the pollution is that the most of the sources are non-point source, though it can be classified into industrial, Hospital, Agricultural and municipal source of pollution it is difficult to indicate this pollution is due to this source. Therefore, managing the Akaki River becomes the most difficult one. According to (A. Mulu, T. Ayenew, and S. Berhe, 2014) come up with the pollution of rivers in Ethiopia becomes worst as industrialization become increasing around the riversides. Almost all the industries and hospitals in Addis Ababa are released their waste directly to the Akaki River, which makes the Akaki River is the most dangerous river for human health and the environment, because of this pollution there are many problems related with the pollutant. Many places around the river are used for agricultural, recreational and industrial purposes; therefore there

may be water pollution-related problems for the people live around the river and the animals.

Conclusions

Both point source (from industrial and domestic effluents) and non-point sources (in the form of solid wastes, sludge and wastewater from Addis Ababa City dwellers and sewer outfalls of pollution have made significant contribution to the worsening of the Akaki Rivers water quality. The poor sanitation facilities and services of Addis Ababa, as well as lack of proper attention to Akaki rivers water quality management, have resulted in the use of the rivers as a waste sink of every kind, ranging from the non-degradable plastic wastes to toxic chemical wastes. At its present situation, the river is not better than an open sewer conveying from weak to medium strength domestic wastewater. Due to unavailability of a continuous data/information on the status of Akaki rivers water pollution and lack of a consecutive time-series water quality analysis, it has become very difficult to see whether or not a linear trend exists in the little and Great Akaki River pollutions. In most studies, the physical, chemical & bacteriological analytical results of the rivers indicate that the river is polluted much beyond the concentration range of the quality specification and the provisional ambient water quality standard developed by the federal EPA and other countries.

Nearly all study results revealed that the rivers' water does not satisfy the basic standard requirements of water supply for human consumption, domestic purposes, irrigation and animal drinking. It is possible to conclude that Little and Great Akaki Rivers are highly polluted as they are serving as principal recipients of untreated wastes that discharge from industrial establishments, domestic, municipal, medical/clinical and other sources. Besides these, it was observed during different surveys that the rivers' water is serving for irrigation, bathing, and human and cattle drinking and all domestic purposes even though it is polluted and unsafe. Because of this water-related human health problems such as diarrhea, dysentery, amoebiasis, ascariasis, and others will be common.

Recommendations

To curb the problem of Akaki River pollution, there should be a well- designed action program and the program has to be strategically approached to attain the intended target. By reducing the amount of wastewater reaching the river, the water quality can be maintained accordingly, all industrial wastes should be treated properly before being discharged into the rivers as per the established standards. Regarding domestic wastewater, it is imperative to improve municipal liquid waste management, which includes providing

due attention to the discharge of latrine wastewater. These can be realized by constructing more on-site sanitation facilities and increasing the dislodging capacity, by increasing the number of connections to the existing sewers, extending the sewerage system to planned areas, expanding and/or constructing wastewater treatment facilities and avoiding pit latrine sludge disposal into the Rivers. Improvement of solid waste management should be taken as an important measure in achieving good water and environmental qualities. Industries and other bodies have to start exercising responsible behavior in all their activities that could contribute to reduce pollution of water and the environment. The involvement of private sectors in waste collection and segregation of solid wastes has to be encouraged. There is a need to regularly assess, monitor and produce periodical report on the status of the Akaki Rivers water pollution. Therefore, establishing an efficient water quality monitoring system on the Akaki Rivers is very crucial. Creation of databases on the status of pollution will fill the data/information gap that is observed now and will support time series analysis in the future. There is a need for communicating facts about the interrelationship of environmental problems and the health threat of using polluted water.

Particularly, practicing horticulture irrigation using the rivers' water seems to continue, the producers and consumers should be aware of the water pollution problems, so that they can protect themselves and the society. Therefore, authorities, bureaus, and organizations that are involved, directly or indirectly, in activities that aim at improving the quality of the city's environment and rivers should encourage full participation of the public. The problem of water quality impairment is not limited to the Akaki Rivers only. Other streams crossing the city and the Awash River with its various impoundments (like the Aba Samuel and Koka Lakes) also require assessment of their qualities. Moreover, studies that aim at providing appropriate solutions for maintaining the required water quality should be given attention.

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