Akaki River| Ethiopia

POLLUTION STATUS OF AKAKI RIVER AND ITS CONTAMINATION EFFECT ON SURROUNDING ENVIRONMENT AND AGRICULTURAL PRODUCTS: Executive Summary 2017

Ethiopian Public Health Institute

የኢትዮጵያ ፌዴራላዊ ዴሞክራሲያዊ ሪፐብሊክ
የጤና ጥበቃ ሚኒስቴር
Federal Democratic Republic of Ethiopia
Ministry of Health

Introduction:

Urbanization is one of the main causes for environmental problems due to the introduction of undesirable materials into soils, water and air. Such changes in the characteristics of soil, water and air, may have a direct effect on the health of people or other living things. In addition, problems associated with human settlements can carry risks for rivers, streams and other water reservoirs if insufficient care is taken and human habitation are sited near to the water bodies. Furthermore, industrialization is among the major cause of surface water pollution in Ethiopia. Industrialization is expansion in Ethiopia particularly in urban areas. Addis Ababa is well known by its numerous industries and most of the industries are located a long side of Akaki Rivers. Accelerated pollution and eutrophication of rivers, streams, springs and other water reservoirs because of anthropogenic activity which results from aforementioned factors are a concern throughout the world including Africa particularly Ethiopia is a case since as developing counties lack and have not stringent regulations that have been implemented to restrict the discharge of untreated wastewater into rivers, streams and other water bodies.

Akaki River, main tributary of Awash River, is hugely polluted because of uncontrolled waste disposal from industry and other sources from city of Addis Ababa. Due to severely pollution of Akaki River, there is a very high risk to human health, and the surrounding environment (air, soil, and water). Exposure to these wastes, which contain toxic components such as chemicals, pathogens, is of great concern, as it poses not only health risks to humans but also potentially unacceptable ecological risks to plants, animals and macroinvertebrates, which are abundant to water bodies. The study conducted in Akaki River revealed that dissolved oxygen sharply depleted (less than 1 mg/L) and 1250 mg/l COD was measured as 400 folder than the normal value (Beyene et al., 2009). As evidence, Aba Samuel dam has already dead because of eutrophication (Gizaw et al., 2004). On the other hand, the country has not stringent regulations that have been implemented to restrict the discharge of untreated wastewater into rivers, streams and other water bodies. As we know the existing pollution legislation of Ethiopia as most developing countries, is weak and generally not adequately enforced into action to protect the water bodies and other environmental entities (Kumie and Kloos, 2006).

Akaki River uses for irrigation of agricultural land, industrial and municipal waste disposal site, domestic purpose, and as a drinking water sources for the Addis Ababa city (as wellfield) and downstream population particularly for Adama city, which is the capital city of Oromia regional state. The river is severely polluted by uncontrolled waste disposal from city of Addis Ababa and industries planted along side of the river (Alemayehu, 2001). Even some trace metal (Cadmium, and Lead) level is found higher than maximum allowable limit in vegetables irrigated with Akaki River (Weldegebriel et al., 2012). Metal exposure study conducted on population nearby Akaki River revealed that the concentration of some trace metal in urine and blood is higher than population live far away from the river at Yeka sub-city even if there was no evidence that proximate river water as a source these metal sources (Yard et al., 2015).

Objective:

To understand the Pollution status of Akaki River and the extent of microbial, and trace metals transportation in food and environmental matrices adjoining the river and its tributaries

Method:

River water samples were collected from 27 different sampling sites of the Akaki River applying the procedure in APHA. The 500-ml water sample, which was intended for anion analyses, was left unfiltered and unacidified. The other unfiltered 250-ml water sample was acidified with 2 ml of concentrated nitric acid; this acidified sample was used later for cations analysis. 1-L Sterilized bottles were used for bacteriological analysis and samples were stored in a refrigerator at 4^oC and subjected to analysis within 24 hours. The water quality parameters were analyzed in accordance with the standard method for the examination of water and waste water (APHA, 1996). The parameters such as pH, Conductivity and Turbidity were determined at sampling site using in-situ instruments. All other water quality variables were analyzed in the laboratory.

The procedure described by Weldegebriel et.al, 2011 was followed for the collection of the vegetable samples. During the dry season of 2017, 38 samples were collected and 15 in the wet season of 2016. In the sample preparation, a microwave digestion system with the aid of acid mixture (6ml of 65% HNO3 and 2ml of 30% H2O2) was used for the dissolution of the vegetable samples. Finally, Atomic Absorption Spectroscopy (novAA400P) was used to determine the metal concentrations.

In the same periods of the vegetable samples collected, 13 samples in the dry (February, 2017) and 12 in the wet season (August, 2016) were taken, using plastic bags, applying a rectangular sampling strategy in the study farms. The samples air dried, grinded, sieved with 2mm mesh, then subjected to acid digestion and analyzed for trace metal concentration by Atomic Absorption Spectrophotometer.

Major findings:

Physicochemical quality of Akaki River

The result of physicochemical, nutrients and trace metal of the Akaki River collected in dry and wet seasons from a total of 27 sampling sites are summarized in this report. The median value of Nitrate, and Nitrite, in Akaki river water in mg/L was 32.21, and 0.34 with minimum and maximum value of 6.36-192.59, and 0.1-4.84, respectively. Approximately 30% of study sites' nitrate concentration was found above the standard. Relatively, high proportion of sampling sites (55.6 %) Nitrite concentration did not comply with any of the standards mentioned. Phosphate median concentration in Akaki River was 0.19 mg/L with minimum and maximum range of 0.0-1.4mg/L and approximately, 32% of river water samples phosphate concentration surpass any of the standard or guideline values. The Akaki River water BOD ranged from 0-319.2 mg/L with a median value of 15.54 mg/L while COD values were ranged between 0–738.67 mg/L. Overall, 95.9 % and 61.1% of river water samples' COD and BOD respectively, did not comply with standards and guideline values.

- ❖ Akaki River is found to be under high impact and is impaired. On the other hand, the river water is used for a variety of purposes such as irrigation, cattle drinking and domestic purposes without prior treatment. For sustainable management of this water resource, environmental protection agencies at different levels and other concerned administrative and/or nongovernmental bodies should take strict as well as technical measures.

Ecological integrity of Akaki River

A total of 2,593 and 1,603 of macroinvertebrates in which belongs to nine orders were collected from 27 sampling sites from Akaki Rivers in wet (August 2016), and Dry (February 2017) seasons, respectively. The most abundant orders during the wet season were Diptera 1,021 (39.37%) and Ephmeropetra 534 (20.59 %) while Diptera 851 (53.98%) and Odonata 434 (27.07%) were the most dominant order in dry season.

Both Shannon (<1) and Simpson (nearly 0) diversity indexes indicating that the presence of elevated levels of pollution and degradation of habitat structure in the studied area. The family level biotic index also showed significant variation among the studied sites in both wet and dry seasons. About 52 % of the sampling sites are classified as poor water quality, which are substantially pollution likely to organic pollution sources during dry season and approximately 83% of study sites in both Little Akaki and Great Akaki were fallen under very poor water quality that are severely organic pollution likely. The family biotic index showed a strong organic pollution level in all sites of the Akaki River.

The habitat classes of Akaki River and its tributary could be categorized into three (marginal, sub-optimal, and optimal). Only 15 percent of the study sites are classified with optimum habitat quality index whereas the majority sampling points are fallen under marginal (45 %), and sub-optimum (40 %). On the other hands, Human disturbance score in the study area is varied considerably among sites. None of the sites is classified as low disturbance. Twenty-five sites out of 27 categorized under severely disturbed class and the remaining two sampling sites are grouped under moderately disturbance class.

- ❖ This study in the Addis Ababa urban area revealed two biologically highly stressed rivers impacted primarily by physical habitat degradation and both point and nonpoint pollution. The low macroinvertebrate composition was liable to physical habitat destruction and poor chemical water quality. This calls the responsible authorities need to take urgent ameliorative and preventive measures to improve the ecological integrity of these rivers as part of efforts to restore their ecology and reduce public health risks within the urban area and downstream river stretches.

Trace metal concentration of Akaki River water, soil and vegetable

The overall concentration of iron, manganese, zinc, chromium, lead, and cadmium in the Akaki River water samples ranged from 0 –38.55 mg/L, 0.01 – 777.0 mg/L, 0 – 0.42 µg/L 0 – 858.4, 0-26.22 µg/L, and 0-7.49 µg/L with median value of 3.36, 1.06, 0.12, 5.33 mg/L, 5.33 µg/L, and 6.23 µg/L, respectively.

A total of 23 soil samples were collected and analyzed for selected trace metals. The values of Zn, Co, Ni and Cd are within the standard limit of the European directives for soil contaminants. However, Cu, Cr and Pb have surpassed this limit.

In this study, a total of 51, widely consumed vegetable samples, of which, 22 are Ethiopian Kale,10 Lettuce, and 14 Swiss chard, were collected and subsequently analyzed for selected heavy metals, Fe, Mn, Zn, Pb, Cr, and Cd. Zn was detected in all vegetable types, where around 51% of the samples have exceeded the amount of Zn when compared to the standard limit of 99mg/kg. The minimum value is 58mg/kg and maximum 157mg/kg. The order of accumulation is in order of decreasing concentration, Lettuce>Swiss chard> E.Kale.

- ❖ Providing different advantages such as taxation, cooperativeness and market value for those industrial firms with treatment plant and good environmental management could be another option. It also necessitates avoiding establishment of additional industries near the river. Continuous monitoring using parameters such as those used in this study should be employed to assess timely status of the system.

Microbial contaminations of Akaki river water and vegetables

The present study attempted to determine the percentage of vegetable contamination with Total aerobic plate count (TAC), coliform bacteria (TCC) and faecal coliforms (FC) as well as their microbial loads through total aerobic count (TAC), total coliform counts (TCC) and fecal coliforms (FC). The overall mean count of E. coli and Non-E. coli from water samples in the present study were 2.09 and >3.48 log_{10} CFU 10 mL^{-1} which is higher than the WHO recommended standard.

The mean count of TC, FC, and TAC on collected vegetables irrigated with Akaki River were 3.22, 1.37, and 4.72 in dry season, and 3.87, 2.57, and 5.09 log_{10}CFU per gram in wet season, respectively. All fresh vegetables were contaminated with total coliform, fecal coliform and total aerobic in dry season.

- ❖ The mean fecal coliform values of Ethiopian kale and Lettuce vegetables exceed the World Health Organization (WHO) and International Commission on Microbiological Specifications for Food (ICMSF) recommended level of 103 fecal coliform g-1 fresh weights in both dry and wet season campaigns. Such findings warn the importance of adequate measures throughout the farm-to-table food chain should be emphasized. Therefore, this calls for farmer's and consumer's awareness on the dangers of contacting with Akaki River water and consuming pathogen contaminated vegetables and the need to insist on properly processed/stored sliced produce needs to be re-awakened. In addition, to minimize potential risks associated with river water irrigation, the proper use of river water as well as cheap and efficient methods to reduce microbial loads in microbially contaminated water used for irrigation needs to be implemented.

Public health concern of Akaki river

The daily exposure of farmers to selected heavy metals through ingestion and inhalation pathways is analyzed and the total chronic daily intake of heavy metals is higher in female farmers (4.80e-4) than male farmers (6.10e-4). The intake of lead and chromium through ingestion of vegetable is higher than intake through inhalation. Even though, it is lower than ingestion, intake through inhalation proves that farmers in the urban and peri-urban areas of Addis Ababa are at risk of occupational exposure to heavy metals. The intake of heavy metal via inhalation is in the order of Ni>Co>Cr>Pb.

Conclusion:

It has been evident from our findings that, the water quality of the Akaki River shows pattern of behavior linked to anthropogenic sources with the intensity of human pressure associated with industrial effluent, domestic wastes and agricultural activities. The assessment of macroinvertebrate taxa provides a clue what happens in Akaki River and the water quality effect on species diversity. Therefore, all macroinvertebrate indices along with human disturbance and poor habitat quality suggests that both little and Great Akaki streams are severely modified by human influences and it needs immediate restoration and rehabilitation tasks.

The Akaki River was shown to be heavily contaminated with non-E. coli & E. coli coliforms and did not meet the WHO guideline criteria for safe irrigation. Target microorganisms commonly used as indicators for the hygiene status of foods frequently exceeded the HACCPTQM and ICMSF limit values for safe consumption. This indicates that the presence of these organisms on produce might be due to a transfer from fecally contaminated irrigation water, which might place consumers at risk. Consequently, we showed that fresh produced vegetables (especially Ethiopian

Kale, lettuce, Cabbage, and swish chard) might contain pathogenic microorganisms and represent a risk for consumers regarding foodborne disease.

Vegetable farms in and around Addis Ababa, which were irrigated with contaminated waters exhibited increased concentrations of metals both in the soils and in the vegetables grown on them. Nevertheless, it was noticed that different vegetables accumulate and translocate variable amounts of metals from the soil into their tissues. Without regard to bioavailability, the vegetables lettuce, Ethiopian kale, and Swiss chard grown in these farms showed cadmium (Cd) at levels that could raise health risk concerns to consumers. However, zinc has the lowest translocation factors in all vegetables analyzed. The findings dictate immediate need for measures to protect the safety of consumers and the general environment.

Keywords: Akaki River, Pollution, Trace metal, Soil, Vegetable, Macroinvertebrate, Season