

# Waste disposal systems of Addis Ababa City, the African Capital, Ethiopia

Hailu Shiferaw (✉ [Hailushi31@yahoo.com](mailto:Hailushi31@yahoo.com))

Addis Ababa University

Fantu Shoamare

Addis Ababa Environmental Protection Authority

Seifu Legesse

Addis Ababa Environmental Protection Authority

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## Research Article

**Keywords:** environmental challenges, health problems, industrial wastes, waste disposal system

**Posted Date:** June 21st, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-614553/v1>

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# Abstract

Industries have played vital roles for economic development that enable people to create new and better livelihoods, more income, and modern life systems. However, Ethiopia has little benefited from industry sector due to limited number of industries with less advanced technologies. This study was conducted in Addis Ababa, the Capital City of Africa. Datasets were collected from 2,204 institutions through structured interview, field observation and GPS points. Datasets were entered, cleaned and analyzed using a relational database system in Visual Basic and MS-access database environment. Spatial distribution of industries indicates that only 18% of industries were found in industry zones, while 82% are outside industry zones and of which 78% of them are found in residential areas. Industrial wastes are disposed either to nearest river or open field. The findings indicate that only 10% of industries treated and disposed their wastes whereas 90% didn't treat industrial wastes but disposed to the environment. The major observed impacts were on: affecting human and animals' health, pollute surface and groundwater, pollute soil and air, trigger firing, damage ditches, block canals and cause over floods, among others. It requires concerted efforts to minimize and avoid improper waste disposal systems so as to realize economically active, environmental suitable and socially conducive capital city for its residents, tourist and business people.

## 1. Background

Reliable waste management system required to properly and sustainably dispose both domestic and industrial wastes. Waste management data provides a comprehensive resource for critical and informative evaluation of waste management options in all waste management programs (Chang and Davila, 2008; Qdais et al., 1997). The required waste management evidences are lacking in developing countries (Buenrostro et al., 2001) but if they are available, they are inconsistent and non-interoperable as they collected from secondary sources at different space and time, which are difficult to be validated and are sometimes based on assumptions not scientific measurements (IPCC, 2006). This case is also common for Ethiopia and its capital. Addis Ababa is a capital city of the country as well as the seat of the African Union and various forms of political, social, cultural and economic activities are going on (Shiferaw et al., 2016). As a result, different types of environmental pollution are arising from such activities. The population immigration from different corners of the country, rapid expansions of industrial sectors, and their improper waste disposal management have resulted in serious environmental and health problems, such as widespread water and air pollution, noise pollution, waste accumulation, serious air pollution and potable drinking water scarcity particularly in the lower catchments of the city. The government officials and experts agree that the dual influences of resource supply and protection of environment will pose a significant challenge to Addis Ababa City's sustainable development.

Environmental problems became an issue of this decade both at local and national levels. In connection with the country as well as city's environmental degradation and industrial pollution, different proclamations and regulations were made at different levels (both at national and regional levels) to prevent and control the ongoing environmental crisis and restore if possible to their natural systems.

Here, it is reasonable to mention some of the efforts made on productions of proclamations and regulations concerning to environmental pollution at the national and regional (city) levels. For example:

1. The Constitution of the Federal Democratic Republic of Ethiopia states that"— every citizen has the right to live in a clean and safe environment — Article 44/1". And "— the government should strive to create safe and clean environment for all citizens — Article 92/1". And also "— any development intervention ensures the safety of the environmental — Article 92/2". In the same article, there is more idea concerning the environment as "—both government and the people should take care of their environment — Article 92/4".

2. Environmental Pollution Control Proclamation: Proclamation No. 300/2002. It stated as "— some social and economic development endeavors may inflict environmental harm that could make the endeavors counter-productive. — the protection of the environment, in general, and the safeguarding of human health and wellbeing, as well as the maintaining of the biota and aesthetic value of nature, in particular, are the duty and responsibility of all; — it is appropriate to eliminate or, when not possible, to mitigate pollution as an undesirable consequence on social and economic development activities" (Negarit, 2002).

3. Environmental Impact Assessment Proclamation: Proclamation No 299/2002. It is also stated as "— environmental impact assessment is used to predict and manage the environmental effects which a proposed development activity as a result of its designing setting, construction, operation, or an ongoing one as a result of its modification or termination, entails and thus helps to bring about intended development. — assessment of possible impacts on the environment prior to the approval of a public instrument provides an effective means of harmonizing and integrating environmental, economic, cultural and social considerations into a decision making processing in a manner that promotes sustainable development. — environmental impact assessment serves to bring about administrative transparency and accountability, as well as to involve the public and, in particular, communities in the planning of and decision making on developments which may affect them and its environment" (Negarit, 2002). In connection with this National Proclamation, local regulation also made at Addis Ababa level, and it is read as follows:

4. Addis Ababa City's Regulation No. 21/2006. It also stated as "— it is found necessary to ascertain in advance the examination of those social and natural environment of negative significant impact to be presumed social and development projects in order to reduce and suspend the following negative environmental impacts on the community and natural environment before the commencement of the work. — it has become necessary to follow up and ascertain those undertaking development activities in the City to be implemented inconformity with the conditions of the principle of sustainable development and without obstructing environmental security; —" (Denb, 2006).

In addition to these proclamations and regulations, different awareness campaigns and discussion forums have been undergoing by environmentally concerned institutions and as well as groups of activators (Fasil and Fasil, 2008). Governmental and non-governmental as well as civic societies were

involved for fighting environmental pollution in the city. The other point of interest is, media and news press agencies are giving special attentions to the environmental issues especially on city's pollution.

However, there is still wider gap between policies (the regulations and proclamations made) and practical contexts (what has been going on the ground) to bring about expected changes on the environment. There may be a lot of reasons for this: some of which may be: especially in the case of Ethiopia in general and Addis Ababa in particular, are the awareness level of the society (Zerfe, 2007; Getaneh, 2008); the accessibility of disposal sites (disposal systems) to dispose waste materials (Shiferaw, 2008; Ambaye, 2015); and implementation gaps of those policies due to weak institutional and accountability arrangements till grassroots' levels (Fasil and Fasil, 2008). Moreover, establishment of such organization was not spatially segregated from other services sites and hence they aggravated the pollution of the environment from time to time (Shiferaw et al., 2016). Therefore, a lot of work should be done to implement those policies, thereby bringing environmental friendly sustainable development as well as maintaining social, economic, cultural and aesthetic values of the city that would help to speed up the economic development and health of the environment as well as the people.

Therefore, this paper is an initiative, which will have immense roles for further research, discussion and policy development to safeguard the environment and health of the society living in and around the city. The general objectives of this study are of three types: (1) to build geo-database for possible pollution sources with particular emphasis on industry sectors and other service providing institutions in the metropolis, (2) to identify and map pollution source points so that researchers and decision-makers will play their respective roles in fighting against pollutions in and around their area of interest, and (3) to offer information on the city's pollution status for industry owners/investors, experts, policy and decision-makers so that they will be able to visualize the potential sources of pollutants in the city so that they design appropriate technologies and actions to waste management systems and mitigate environmental pollution which would contribute for sustainable socio-economic development of the city.

## **2. Materials And Methods**

### **2.1. The study area**

This study is conducted at Addis Ababa City, the capital city of Ethiopia and Africa. It covers an area of about 54,000 sq km (Fig. 1), which extends from 976,756.1 m to 1,005,959.8 m North and 461,504.2 m to 489,590.6 m East.

### **2.2. Data collection and analyses**

Using structured and close ended questionnaire, individual interview was conducted for industry owners or manager/technical managers. Five teams of surveyors with five individuals in each team and one coordinator were organized to collect data throughout the city. A complete census was carried out between August and November 2007 on every industry and other service providing institutions found in

the metropolis. Besides to individual interviews with industry owners/managers, geospatial information was collected using Global Positioning System (GPS) each institution and personal observations on industry's effluents and disposal systems.

After the data were collected, data entry was carried out into an organized relational database system in Visual Basic (VB6) and cleaned. The required information was generated by creating different entity-relationships. The organized report was analyzed and generated using VB6 and MS-Access, ArcGIS9.1, and Spreadsheet, respectively (Fig. 2). In addition, different steps of GIS analyses were performed to come up with the final maps produced and spatial analyses were carried out to identify pollution sources and nearby natural features (e.g. rivers) those are used for disposal sites.

## **3. Results And Discussions**

### **3.1. Spatial distributions of polluting institutions**

The finding revealed that more than 2,204 industries and service providing institutions were registered in the city. These industries and service providing institutions include (1) Tannery and Leather, (2) Textile, (3) Chemical industries, (4) Plastic, (5) Printing, (6) Wood-Pulp-Paper, (7) Metal, (8) Metal and non-Metal, (9) Mine, (10) Cement, (11) Food & Beverage, (12) Garage and Warehouse, (13) Tobacco, (13) Electronics, (14) Health Facilities (hospitals, clinics, pharmaceuticals and laboratories), and (15) Religious centers from sound pollution perspective. Looking at the spatial distributions of these institutions, they are not spatially segregated from other types of land use systems and they are not in harmony with planned spatial sites (Fig. 3).

Figure 3 indicates three findings: 1- the establishments of industries are following the north–south expansion of the city, 2- industries established following the flow of rivers in the city, and 3) industries are also found mixed with other land use services such as residential areas. On the other hand, most rivers are preferred sites for waste disposals without any differentiations whether hazardous industry waste and hospital wastes or domestic wastes. That is, wastes are discharged to nearby rivers. One of the findings indicates that about 45% industries are found within 50 m from nearest rivers and discharge their effluents to the nearby rivers (Fig. 4). This shows that these areas (rivers) are default and also preferred waste disposal sites.

In addition, the spatial distribution of industries in the city shows that only about 18% of industries were found in industry zones, while 82% of industries are out of the industry zone (Fig. 5). Surprisingly, 78% of processing organizations (industries and health facilities) are found in residential areas. This indicates that most pollution types, which include solid, liquid, noise and even particulates from different metal and non-metal workshops are affecting the lives of the society and the environment provided that they disposed these waste products arbitrary around and or nearby their vicinities.

### **3.2. Waste types and disposal systems**

It was mentioned early that Addis Ababa Environmental Protection Authority (AAEPA) registered more than 2,204 industries and service providing institutions, which are considered as possible pollution sources in the metropolis. Industry owners/managers were asked whether they treat industrial wastes before they release into the nearest river or open field, and their replies are summarized and presented (Fig. 6). Of the requested and visited industries, only 10% of them have treatment plants whereas 90% do not have treatment plants. Similarly, about 42.5% of organizations produced solid wastes, and about 41.7% of organizations didn't state which kind of wastes that the organizations produced.

Considering waste types, some industries were counted twice as disposal systems are different and required different types of technologies to properly dispose. For example, if an organization produced solid and liquid wastes, it is counted as twice as the types of wastes and disposal systems differ. Although we had about 2,204 industries and service providing institutions were registered, based on treatment types and status, particularly for liquid and solid wastes, about 2,776 were counted, which have both solid and liquid wastes. Different kinds of wastes were produced from such institutions such as solid, liquid, particulates, noise, smoke/gas, and one or more of these were produced (Fig. 7). However, we mainly recounted two major waste types (solid and liquid) for this report. The very interesting finding, in Fig. 7, is that 30 % of organization/industries managers do not have a record of waste type that their organization produced, and even the largest number comprises this category. They do not know whether their industry/organization produced solid, liquid or which types of waste. These groups could not think to design any prevention and control mechanisms. This also goes with their educational levels and global thinking that they will be unable for the competition on the local as well as global markets.

If we looked at only solid and liquid wastes, about 30% of the organizations released their solid wastes to open field while only 31.6% of liquid wastes were released to municipality sewerage system; and only 1.5% of both solid and liquid wastes were recycled and reused whereas the rest released to the environment without any treatment (AAEPA, 2007). Most industries produce solid and liquid wastes but there are also institutions released noise (unwanted sound), particulates, and other types of pollution (Fig. 7). Health facilities also produced and released hazardous waste products to rivers and nearby areas (Mussie, 2008) instead of burning under incinerators. The health facilities considered in the survey were clinics (higher and medium), hospitals, pharmaceuticals, laboratories and health centers (Fig. 8).

There are two main pollution sources: point and non-point sources. Both point and non-point (diffuse sources) of pollution have resulted in many quality challenges to the water, soil and the environment. For example, regarding water quality, at least two important water quality problems in surface waters: eutrophication (nutrient enrichment) and contamination by hazardous organic compounds (Zerfe, 2007). Zerfe farther explained that almost all the industrial effluents discharged into the river system are untreated and their pollutant loads both organic and inorganic are observed to be high, and also the highest value for Ammonia was found in her study in almost all sites, displaying the high risks that the discharge of waste water causes for the deterioration of ecosystem quality. Hence, the overall classification of the water quality of city's rivers is ranged from "moderate" to "very bad" water quality. Parameters such as different ions, heavy metals, fecal coliforms were found as the major threats

impairing the water quality for uses such as irrigation, swimming and aquatic ecosystem preservation (Zerfe, 2007). Water quality in almost all the assessed sites along the Kaki Rivers (two main rivers of the city at the lower catchments) was found to be deteriorated and not meeting the WHO, USEPA or STN 75 7221 guidelines for river water (Zerfe, 2007).

Regarding the impacts of pollution on soil quality, the pressure on soil quality and the need for sustainability of soil fertility is an ever increasing due to the issues related to the population increase and soil pollution becomes a hot topic (Cachada et al., 2018). The causes and types of soil pollution such as waste disposal, mining, agrochemicals, industry, and atmospheric deposition (Cachada et al., 2018). These polluted soils are causes for poor food safety (nutrition) health risks of the users. Hence, both soil and liquid wastes released from industries and service providing institutes mainly affect our daily lives and impaired long-term health, socio-economic and environmental stabilities of the city.

### **3.3. Environmental Management Systems**

Environmental Management System (EMS) is an application implemented by industries to attain international standards and ISO 14000 family certification so as to benefit from clean production systems for international markets competitions. EMS application was also considered as one means of environmentally cleaned and sustainable production system so called “cleaner production”, and thus industries were assessed accordingly. When the EMS application was accessed, only about 1.5% (34/2204) of organizations were aware of EMS and they started EMS application and about 19.5% (429/2204) of organizations aware about EMS but didn't start anything (Fig. 9). However, about 78% (1721/2204) of organizations stated that they didn't know about EMS (Shiferaw, 2008). Therefore, these all indicate that awareness and capacity of environmental friendly products for sustainable development at all levels should be in place before any legal concrete measures will be taken on the polluters.

## **4. Summary**

The findings revealed that more than 2,204 industries and service providing institutions were registered in the city and most of them produce different pollutants. Of the surveyed industries, only 10% of them have treatment plants whereas 90% do not have treatment plants. The spatial distribution of industries in the city shows that only about 18% of industries were found in industry zones, while 82% of industries are out of the industry zone. About 42.5% of organizations produced solid wastes while about 41.7% were not stated which kind of waste produced from their organizations. About 45% industries are found within 50 m distance from nearest river and most rivers areas were default and preferred site to waste disposal systems, and 30% of the organization in the city are released their wastes to open field. Based on the information analyzed, only 31.6% of liquid wastes were released to municipality sewerage system; and only 1.5% of both solid and liquid wastes were recycled and reused while the rest released to the environment without any treatment. When the Environmental Management System (EMS) application is considered, about 1.5% of industry owners are aware and started EMS application and about 19.5% of organizations aware about EMS but didn't start anything. However, about 78% of organizations stated that they didn't know about EMS. Therefore, these all indicate that awareness raising at all levels should

be in place before any legal concrete measures will be taken on the polluters. A lot of work should be done to implement those policies instruments and EMS, thereby bringing environmental friendly sustainable development as well as maintaining social, economic, cultural and aesthetic values of the city.

## **5. Recommendations**

There are no proper waste disposal systems for both household wastes and industrial effluents. This leads to release wastes anywhere without considering their consequences to the environment, health and socio-economy at large. Hence, we recommend that industries should install appropriate treatment plants to treat their wastes so that the effluents attain the required standard before discharged into the receiving environment or water body. From the government side, proper control and management systems are insufficient until grass-root levels, which has to be strengthened and facilitated. One of the tools could be setting up practical means of incentives for the actors and/or polluters-pay systems against environmental activities. Moreover, awareness creation and capacity building among societies and industry owners/managers should be prioritized as lack of awareness is one the main root causes for environmental pollution and degradation. The simple example for measuring awareness of the dwellers is lack of domestic waste removal through the municipality system but instead connecting toilets or septic tanks to the river systems. Moreover, appropriate means of collection of solid wastes should be encouraged such as segregations of wastes from the sources and change the waste to useful materials, like compost. Therefore, the local government has to do more to aware the public and particularly the industry owners/managers and service providing institutions to give attention to the environment besides to establishing and exercising tools of encouragement or punishment as a polluters-pay principles applications to the actors against environmental protection activities. Then, waste disposal systems are enforced and effective for environmentally friendly and sustainable development endeavors of the city.

## **Declarations**

### **Competing interest**

Authors declare that there is no conflict of interest

### **Acknowledgement of funding**

The authors acknowledge Henrich Boll Foundation, Germany for financial support to conduct the survey on Addis Ababa Environmental pollution. This publication is to remember the second author, the Late Mrs Fantu Shoamare. Rest in peace in heaven.

### **Credit author statement**

HS and FS and SL conceived the idea. HS, FS and SL designed questionnaire. HS conducted the survey, did analysis and draft the manuscript. All authors read, revised and approved the manuscript.

## **Ethical Approval and consent to participate**

This study didn't need an ethical clearance/approval as it doesn't touch human health but the survey was approved by Addis Ababa Environmental Protection Authority.

## **Consent to Publish**

We didn't use third party data to request consent to publish as the datasets are collected by the authors.

## **Availability of data and materials**

We will make available the data and materials upon request.

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## Figures

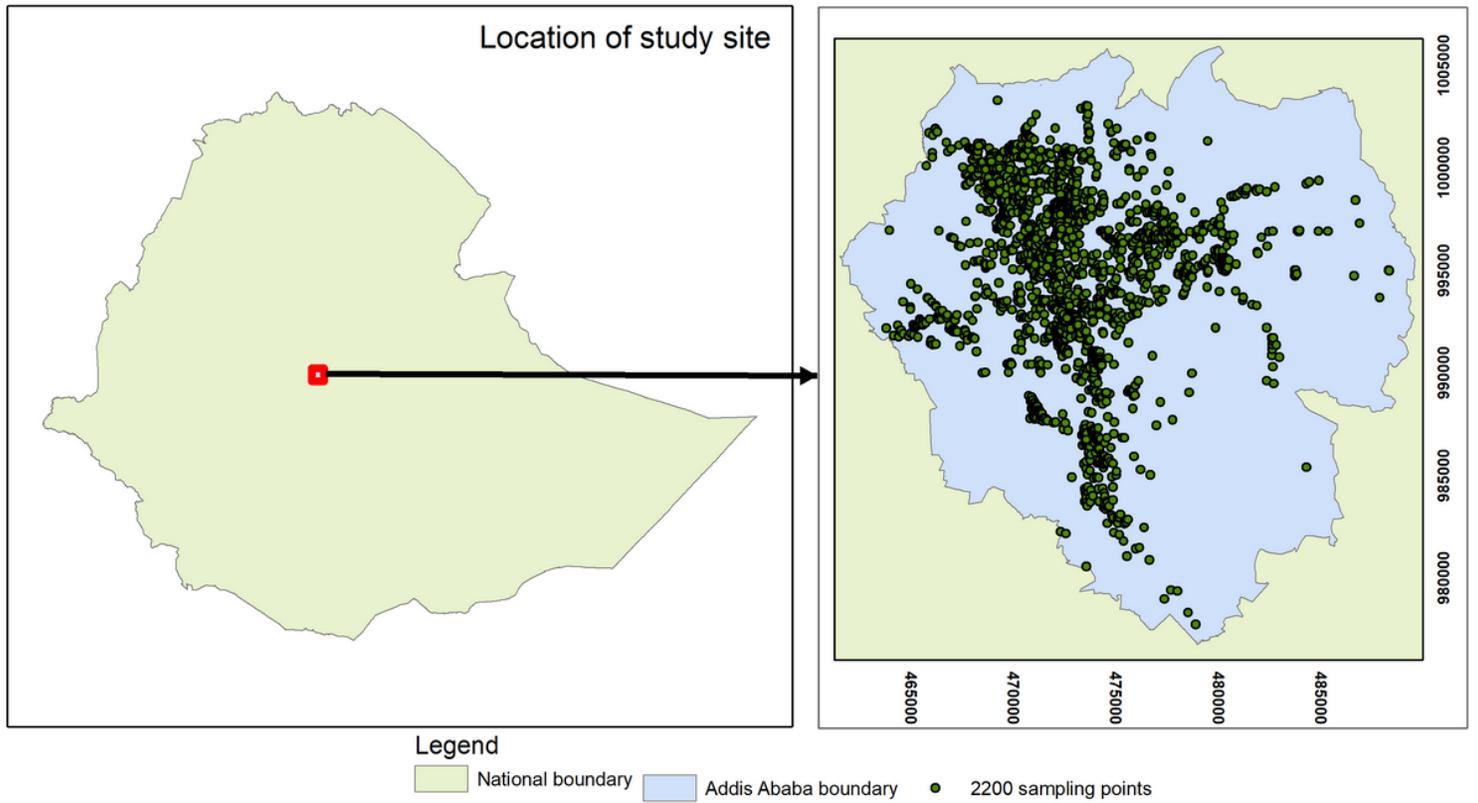


Figure 1

Location of the study area

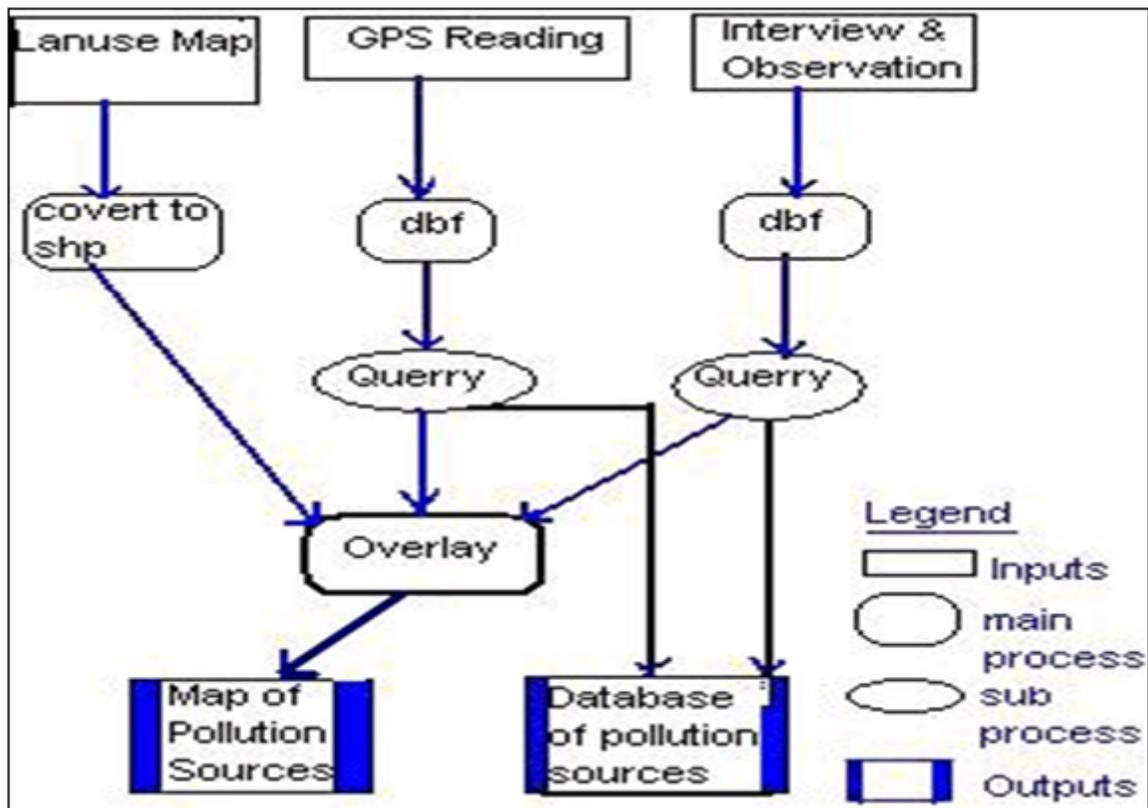


Figure 2

General methodology flowchart

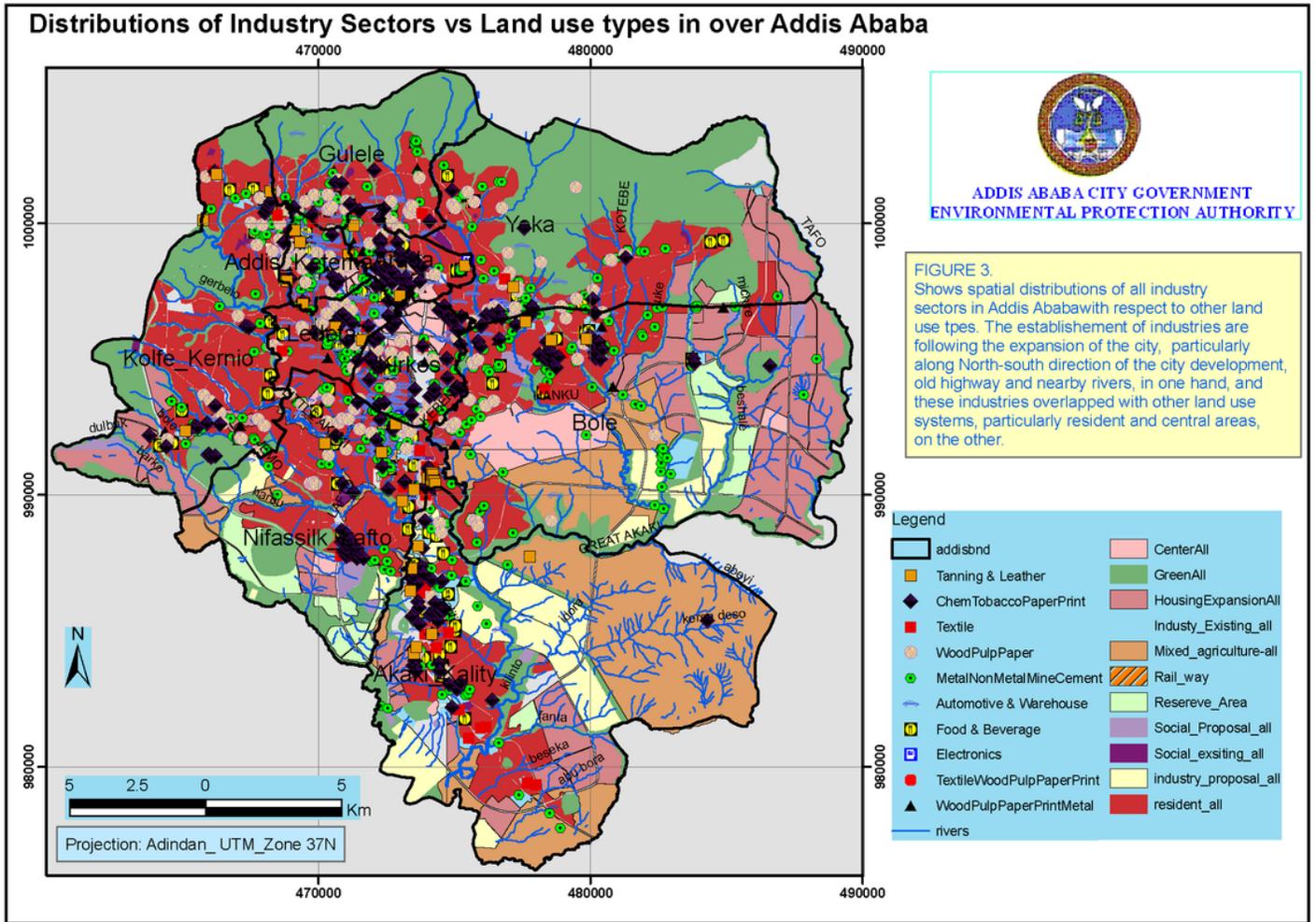
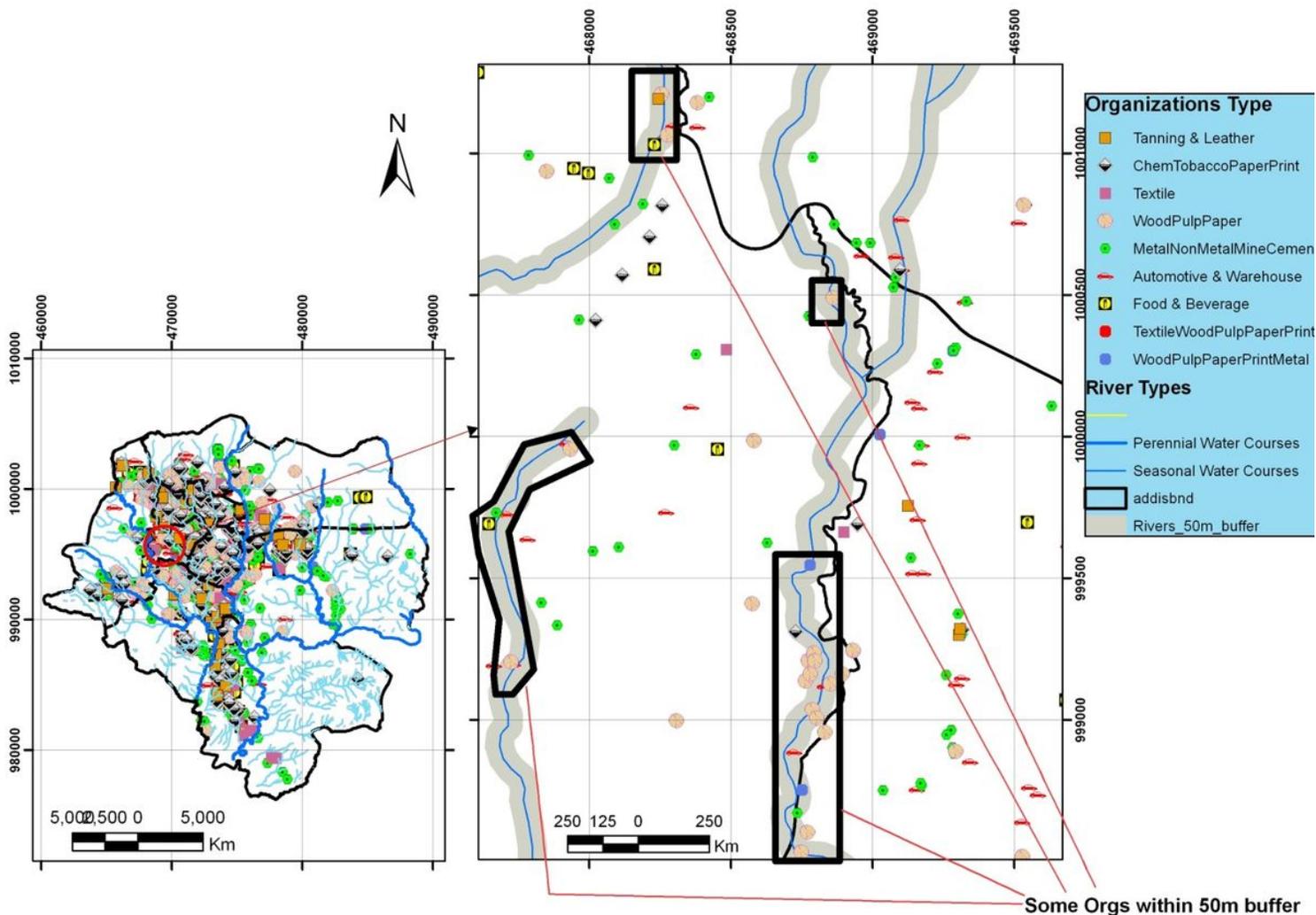


Figure 3

Spatial distributions of all industries by types with respect to other land use plan.

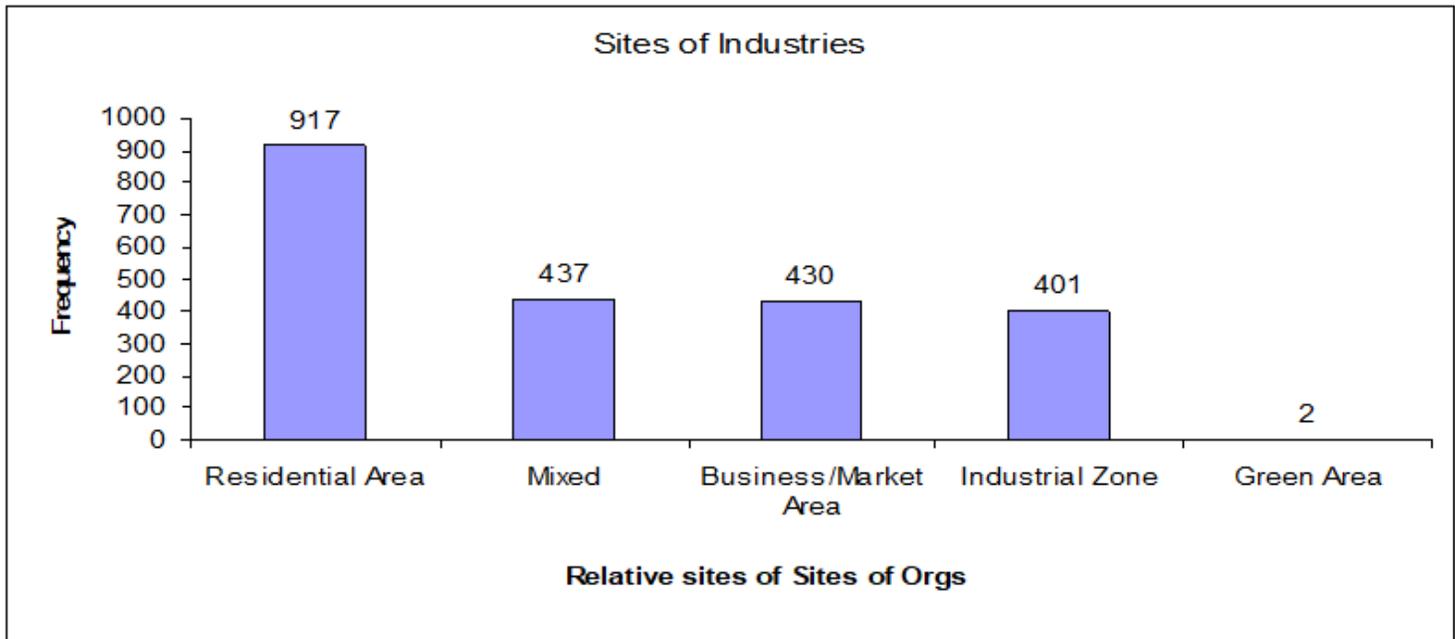
# Industry Sector versus River



Projection: Adindan UTM 37N

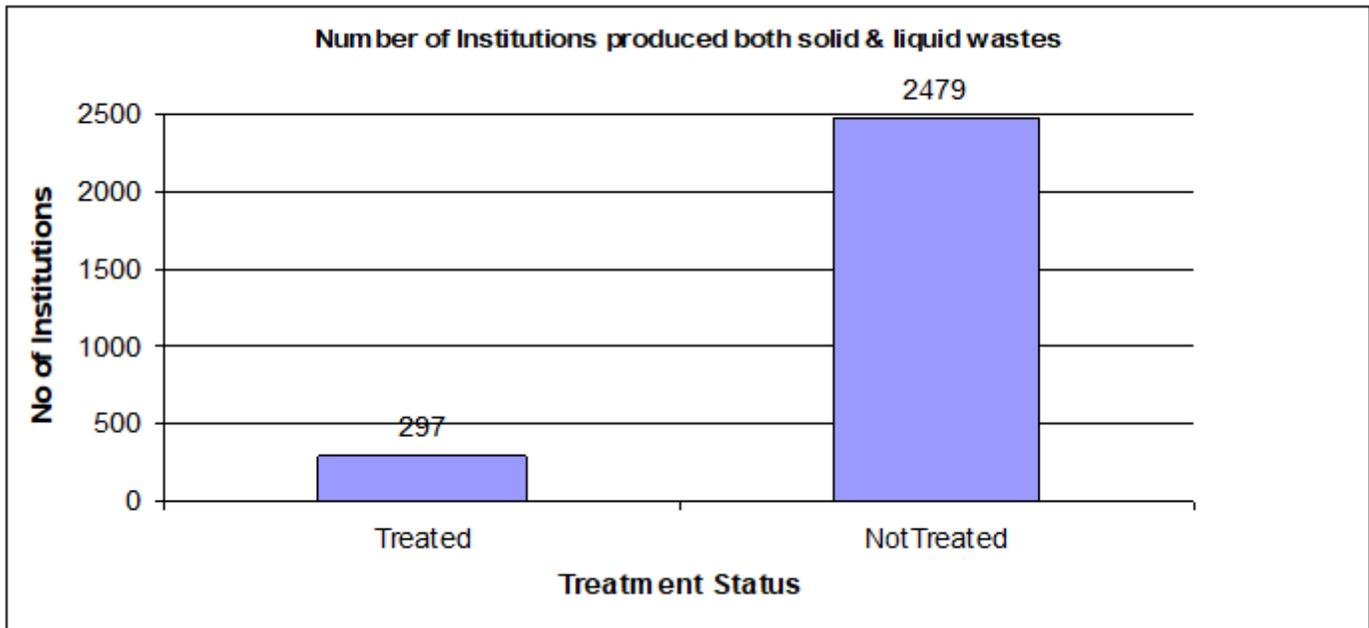
Figure 4

Spatial distributions of polluting industries with respect to rivers in the city and zoomed rivers within 50m buffer.



**Figure 5**

Relative sites of industries in the city as compared to residency and market.



**Figure 6**

Treatment status of industrial wastes before they were disposed

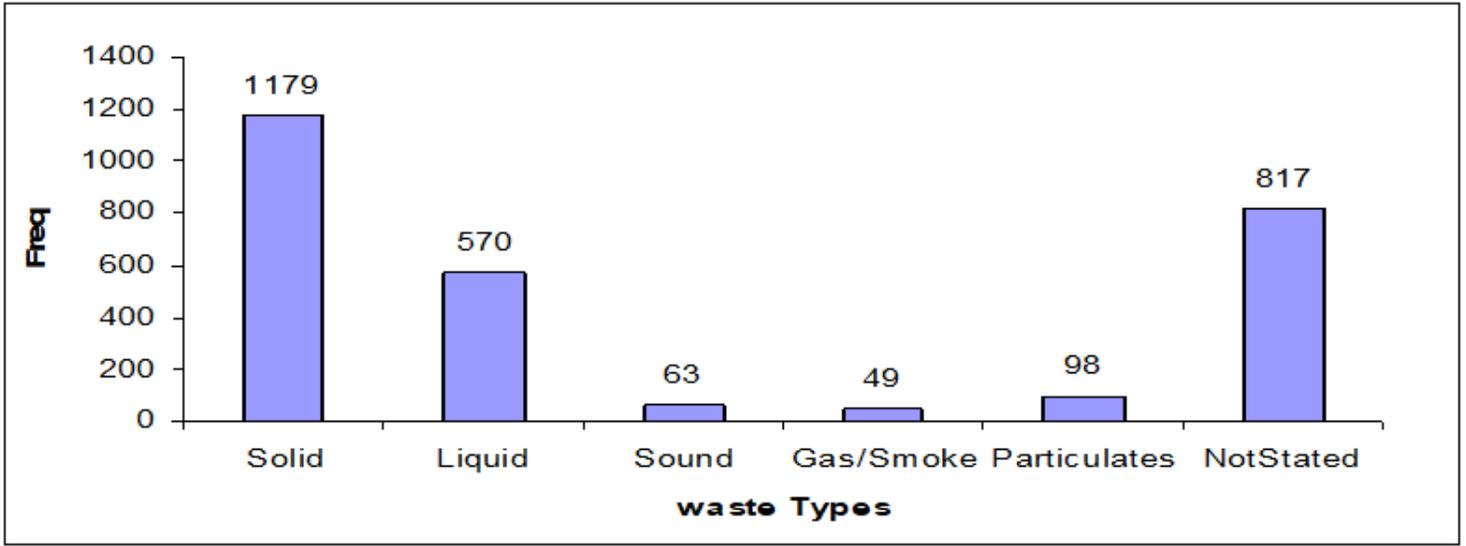


Figure 7

Types of wastes from industries and service providing organizations in Addis Ababa

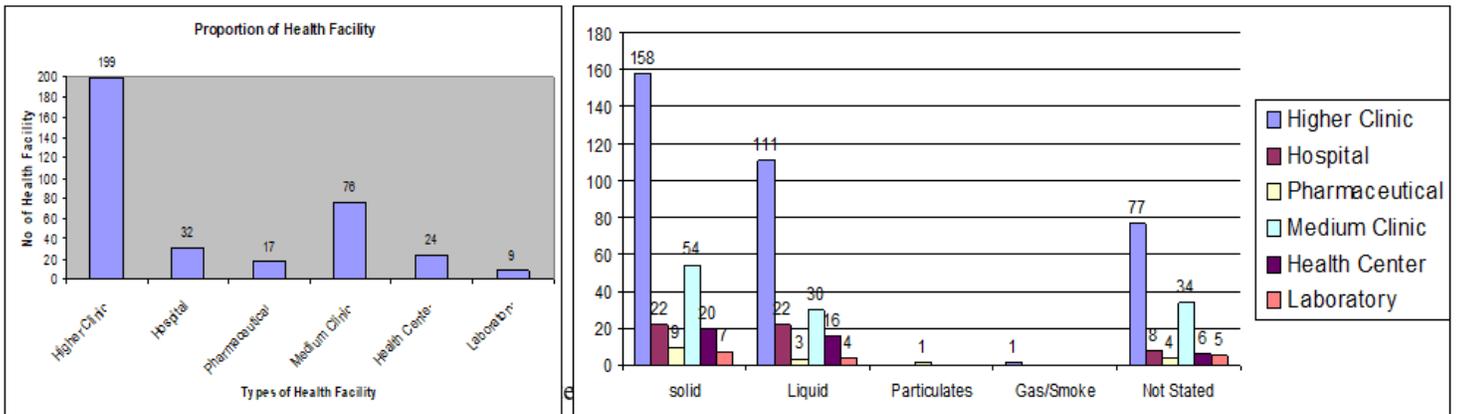
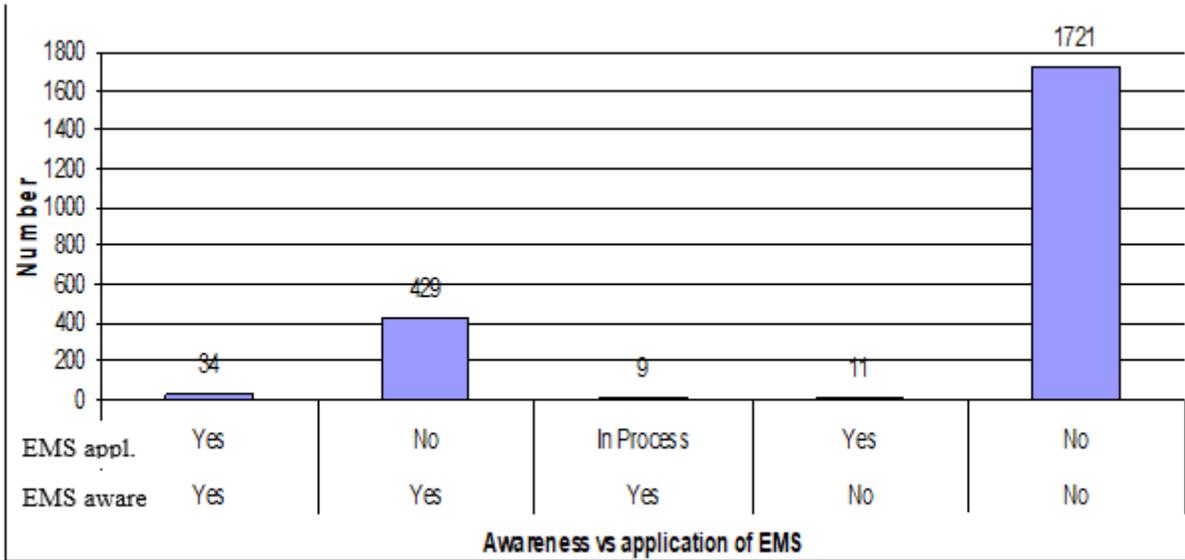


Figure 8

Health facilities surveyed (left) and registered as pollution source (right)



**Figure 9**

Comparison of industries those have awareness and implementation status of environmental management systems (EMS).