IMPACT OF TANNERIES ON MODJO TOWN AND SURROUNDING AREA

FINAL REPORT

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Abbreviations and Acronyms

CETP	Common Effluent treatment plant
CSE	Conservation Strategy of Ethiopia
CSIR-CLRI	Council of Science and Industrial Research, Central Leather Research Institute,
EA	Environmental Assessment
EFCCA	Environment, Forest and Climate Change Authority
EMB	Environmental Management Branch
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
EPC	Environmental Protection Council
EPE	Environmental Policy of Ethiopia
ETB	Ethiopian Birr, the National Currency
ETP	Effluent Treatment Plant
FDRE	Federal Democratic Republic of Ethiopia
ICC	International Chamber of Commerce
MCM	Million Cubic Meter
MoEDAC	Ministry of Economic Development and Co-operation
PLC	Private Limited Company
VOC	Volatile organic carbon

Executive Summary

This report is on the assessment of impacts of tanning industries on Modjo town. The studied report provides specific elements of knowledge for a better understanding of the environments and the expected potential impacts of the tanning sector on Modjo town. In addition, it stipulates critical mitigation measures required in order to minimize/offset such identified consequences on the peculiar natural and social environment.

The methodology used for the study includes data collection both from primary and secondary sources; identification and analysis of significant environmental issues on the basis of those data; choosing mitigation and enhancement measures; and developing environmental protection, monitoring and management plan.

This impact assessment study was conducted according to the country legal requirements and the report is submitted to Solidaridad Ethiopia. The executive summary of the study – including the major impacts and necessary mitigations measures to minimize the negative impacts occurred during tanneries operation in Modjo town.

The study discusses major environmental and social issues and constraints that can arise from the tanning industry operation in Modjo town. The impacts identified are divided according to their nature into negative or positive. The tanning industry operation is characterized by long-term significant impact during operation activates. The major positive impacts of the industries are mainly those of economic benefits at the national, regional and local level due to creation of employment, export earnings as well as technology and capacity building for the citizens, while the major adverse impacts are mainly results due to the generation of environmental pollutant wastes from the various units. Among the adverse impacts nuisance odor, emission of particulate matter and wastewater effluents are the main concerns associated with the tanning industry. Cost-effective and environmentally sustainable techniques that can mitigate the adverse impacts were proposed. Emphasis is given for best available techniques for prevention of air emissions and wastewater effluents and control of their environmental impact.

For effective implementation of mitigation measures, environmental management must be fully integrated with the overall factory management effort at all levels , environmental authorities engagement and other stakeholders involvement which should be aimed at providing a high level support and commitment to the tanning industry to sustainably operate throughout its life.

1. Introduction

Leather industry has been a mainstay for employment and revenues in Ethiopia for more than 80 years of manufacturing experience. The legacy still continues today with leather sector being among the major industrial sector in terms of sales as well as employment generation in the country. Industrial areas in and around Addis Ababa and Modjo are major leather centers within the country and houses more than 80% of leather processing units currently operating in Ethiopia. Some of these industries have been operational for several decades while most of them have entered business the last two decades. However, these leather industries have created a negative image in the society not only because of pollution causing potency but also of its dirty nature. Serious attention is invited to the fact that leather industry is one of the most polluting industries. In tannery industries, over 80% of the organic pollution is generated in beam house of which 10% is derived from soak liquor, 60% from unhairing and liming, 15% from deliming and bating, remaining 15% from the rest of the tanning process. The leather industry consumes large quantity of water; about 40-50 liters per kg of hide processed (Dixit, 2015).

The tannery waste management becomes a matter of serious concern in the recent years. The public pressure is mounting on the tanneries to make leather processing environmentally sustainable not only by local pollution control authorities but also by buyers who do not want to buy any more from tanneries without effective environmental management system in place. The big brands have come out with their own method for assessing the tanneries on these issues. The assessment of the extent of pollution and identification of sources through process audit has been carried out in different tanning clusters in many countries in order to evolve effective appropriate strategies for mitigating the pollution related problems faced by the leather industry.

In order to abate the environmental problems of leather industries and to sustain the economic and technological contribution of leather manufacturing industries in Ethiopia, the government has enforced all the tanning industries to have proper treatment system up to secondary level to comply with discharge standards. Of the 28 tanneries currently existing in Ethiopia, 12 tanneries are found in Modjo town, where most of these tanneries are operational.

The study area covers five kebeles in Mojdo (Shera Debandeba, Tafi Abo,Momo Shoki, and Muda Senekele,Kurma Fetal),where almost all tanneries are found and the industry impacts are felt. .

An impact assessment is required to investigate the impact of tanneries on Modjo town and propose the required mitigation measures especially on solid and liquid waste managements for sustainable growth of the sector.

1.1. Objective of the study

1.1.1. General objective of the study

The General objective of the study is to investigate the impact of tanning industries on Modjo town and the surrounding environment.

1.1.2. Specific objectives of study

The Present study has been conducted to fulfill the following specific objectives:

- To investigate, analyze the impacts of tanneries on surface and ground water, solid waste disposal sites on soils and the nuisance effect on the community.
- To describe the existing baseline socioeconomic features of the study area.
- To identify the positive and negative social impacts of the tanneries in the study area and prepare enhancement and mitigation measures respectively.
- To devise EMP for mitigation of adverse impacts including monitoring program
- To develop solid waste management strategies
- To study the health and safety aspects of the tanning industries during operational activities
- To ensure environmental considerations are addressed and incorporated into the decision making process of sustainable leather industries operation;
- To anticipate and avoid, nuisance or offset the adverse significant biophysical, social and other relevant effects of the tanning industries.
- To promote development that is sustainable and optimizes resource use and management opportunities.

1.2. Scope of the Study

The scope of the study is limited to impact assessment of tanneries on Modjo town especially Modjo river and solid wastes disposal areas stretch along with the relevant components of the environment.

1.3. Methodology

For the impact of tanneries on the Modjo town study the following methodologies were deployed:

Document review: previous documents related to the tanning industries impact assessment studies have been reviewed. The documents which give insight into the natural, regulatory (legal) and socio economic environments, in which these tanning activities would occur, have also been reviewed. Scoping seeks to identify an early stage, from among all of the tanneries possible impacts and the entire alternative that could be addressed, that could constitute the key and the significant issues.

This exercise has identified the activities that have the potential to interact with environment. The scoping exercise constituted of the following:

- Gather and review existing documents relative to the tanning industries (tannery operational documents, feasibility study , similar studies elsewhere through literatures)
- Gather and review environmental and socio-economic data relevant to the proposal development area.
- Review of relevant legislative requirements, national and international environmental standards and guidelines
- Consulting with tanning stakeholders and other potentially interested and affected by the tanning industries.
- Site visit and observation for key environmental aspects related to the study
- Conduct key stakeholders consultation like farmers, social affairs offices, health bureaus , land administration, environmental offices of the Modjo town

Laboratory Analysis: To investigate pollution load on ground water, river water, and open landfill sites samples were collected and analyzed by third party laboratory testing entities to scientifically know the pollution level. The sampling and methodology used for laboratory analuysis compromises the following:

- Samples were collected and analyzed by third party from the upper and lower catchment of Modjo river i.e. before any tanneries effluent are discharge and after all tanneries wastes are discharged from the tanneries.
- Samples were collected and analyzed by third party from ground water samples to investigate whether the ground water is polluted or not from the tanneries as the town ground

waters are found in the upper catchment

- Soil samples were collected and analyzed by the third party from open landfill and river side from the downstream of the Modjo river
- Vegetable samples (tomato, green pepper and cabbages) were collected from Modjo town vegetable market sourced from Koka in lower catchment of Modjo river to evaluate
- Standard test methods were employed to analyze the available pollutants present in the respective sample (specific methodology used is annexed with the laboratory test results)
- Evaluate the test results against the standards, norms and regulations

The scoping assisted in the identification gaps in the environmental and socio-economic information that need to be addressed to allow an informed impact assessment later in the impact assessment process. The detail impact study of the envisaged study was conducted in three stages as described below:

1.3.1. Stages of study conduction

Step I: The first phase started by acquiring existing tanning industries documents (feasibility study report, and operational activities, etc.), location and topographic maps, soil & water test reports, hydro- metrological data and hydro-geological data of the Mojdo area. This was followed by an intensive desktop review of available documents.

Guidelines for socially and environmentally responsible manufacturing of leather were thoroughly studied in order to design the structure of the report. Checklists to collect data on baseline, social , environment impact and economy impact at the operational phase were designed based on the information obtained from the desktop review and others.

Step II: Any available information and data that describe the most relevant features of Modjo town where the study was conducted were collected using the prepared checklist during the second phase of this study. These include important features of the leather industries that would have direct impact on the environment. In addition, visual and scientific information was gathered on the biophysical and socio-economic conditions of the project area from proponent and credible government institutions.

Step III: The last phase of the study has been allocated to synthesis and analysis of the collected information based on the available standards, legal requirement, etc. This enabled to predict the possible environmental impacts that could result during the operation life of tanneries.

Possible mitigation measures were also identified to prevent, reduce or minimize the environmental impacts. Furthermore, impact assessment findings and the mitigation measures that are recommended to address the impacts were also included. In addition monitoring and/or auditing mechanisms were designed to those impacts that need an ongoing monitoring in the life span of the tanneries to address the identified environmental impacts in the study.

1.3.2. Baseline Investigation Methods

An environmental and socio-economic data were assessed in greater detail to ensure that all of the tanning industries activities and their consequences were considered in full. Description of the environmental baseline conditions includes the present state of the environment in the presence of tanneries activities. This translates to essentially characterizing the existing baseline environmental and socio-economic conditions including establishing the prevailing conditions for a range of media such as:

- Natural environment media such as air, water, soil and ground water, flora and fauna.
- Socio-economic media such as demographics, economic activity and service provision.

A significant amount of data already exists for the region obtained through the field work, desk based data gathering and interpretation. The existing environmental and social conditions were established using the data and the results of previous studies and by completing the following main tasks:

- Investigating the necessary primary data and conducting a detailed review of all secondary data sources. Significant data acquisition surveys and studies have been carried out in the envisaged study area and in the vicinity.
- Production of an updated stakeholder list detailing persons/organizations and groups with an interest in the tanning industries
- Meeting with local community representatives and local authorities to assemble new and revised socio-economic baseline information on the tanning industry found in Modjo town.

Both existing secondary sources and results of the new studies were analyzed and integrated into a coherent description of baseline characteristics.

1.3.3. Environmental Impact Identification Methodology

Identification of key impacts that all potentially significant environmental impacts (adverse and beneficial) are identified and taken into account in the process. To identify the tanning industries environmental and social impacts during the operation phases have been considered. In addition, concerns and issues raised by members of the community, tanners, and other stakeholders during consultation were included in the process. Through such steps, the activities involved in the tanning industries and the possible interaction of each activity with environmental and socio-economic receptors were assessed using a simple matrix where a tick mark is put in the matrix for an

activity considered to have an influence on a receptor. The key inputs for the identification of the receptors include the legislative review, the environmental baseline, the socio-economic baseline and stakeholder consultation. The environmental and socio-economic baseline were compiled using a combination of existing data and the results of a number of data acquisition focused baseline survey and stakeholder consultation programs**.**

Table 1: Physical Environmental receptors

Receptors	**Description**
Air	Air quality in Modjo town
Surface water	Water quality of Modjo river
Ground water	The ground water resources and aquifers of areas where tanning industries are using for the production
Soil	The soils of areas in which the tanners disposes their solid wastes

Table 2: Biological Environmental receptors

Receptors	**Description**
Flora	Plant species that occur in areas in which tanning activities are going on
Riverine vegetation associated with plant species	Riverine vegetation and plant species that occur in areas where the tanning activities are conducted
Indigenous trees	Indigenous tree species that inhibit areas where the tanning activities are conducted
Terrestrial fauna (birds, mammals, amphibians and reptiles)	Animal species that inhibit the terrestrial habits where the tanning activities are conducted

Table 3: Socio-economic receptors

Socio-economic Receptor	**Comments**
Population growth	Population growth will take place within the tannery areas and the town
Employment	Employment opportunities are the perceived benefits from the tanning industries
Migration	inflow and outflow of people will take place
Better access to infrastructure	local people will have better access to schools, market etc.
Local economic development	Promotion of various small and micro level
Communal land	Losing of communal land due to the tanners
cost of living	increased cost of living mainly for government employee
Vulnerable people	Aged and orphans are vulnerable
Prostitution	presence of commercial sex workers

2. Environmental scoping

In the aim of deciding upon the limits of the study area for the analysis of the impact of tanning industries in Mojdo town and drawing the list of activities and impacts to be studied during the assessment, the consulting firm carried out an initial environmental examination and scoping. The scoping exercise has been carried out with the following main objectives:

- To define the limits of the study area,
- To define list of activities, type and magnitude of the tanning industries, and
- To define list of impacts to be studied.

In order to carry out the above tasks, the firm employed different tools and techniques relevant to the study. Use of environmental scoping checklists and consultation of different stakeholders (including experts, tanning industry benefited and affected peoples, local administrators and people, etc.).

2.1 Limits of the Study Area

The impact assessment study is conducted for those areas that would be influenced by the impact of the tanning industries operation in Modjo town (mainly five kebeles). The land adjacent to the tanning industries, effluent discharge receptor, and their waste disposal sites are the most impacted areas either directly or indirectly impacted by the operation of the tanneries. The socio-economic and environmental impacts can, however, be felt beyond those limits.

3. Legal and Regulatory Frameworks

3.1. The Constitution

The constitution of the Federal Democratic Republic of Ethiopia provides the overriding principles and legal for all legislative frame-works in the country. The concept of sustainable development and the environmental rights of the people are enshrined in the constitution by the following articles that stipulate the rights of peoples in country.

Article 43: The Rights of Development

- The Peoples of Ethiopia as a whole, and each Nation, Nationality and People in Ethiopia in particular have the right to improved living standards and to sustainable development;
- Nationals have the right to participate in national development and, in particular, to be consulted with respect to policies and projects affecting their community;
- All international agreements and relations concluded, established or conducted by the State shall protect and ensure Ethiopia's right to sustainable development; and
- The basic aim of development activities shall be to enhance the capacity of citizens for development and to meet their basis needs.

Article 44-Environmental Rights

1. All persons have the right to live in a clean and healthy environment.
2. All persons who have been displaced or whose livelihoods have been adversely affected as a result of State programs have the right to commensurate monetary or alternative means of compensation, including relocation with adequate State assistance.

These constitutional provisions have served as the guiding principle of all activates that are related to policy formulation, strategy development and the formulation of legislative and institutional framework for environmental protection.

Article 92-Environmental Objectives

1. Government shall endeavor to ensure that all Ethiopians live in a clean and healthy environment.

2. The design and implementation of programmes and projects of development shall not damage or destroy the environment.

3. People have the right to full consultation and to the expression of views in the planning and implementations of environmental policies and projects that affect them directly.

4. Government and citizens shall have the duty to protect the environment.

3.2. The Conservation Strategy of Ethiopia (CSE)

The CSE, approved by the Council of Ministers in 1996, provides a comprehensive and rational approach to environmental management in a very broad sense, covering national and regional strategies, sectoral and cross sectoral policies, action plans and programs as well as providing the basis for development of appropriate institutional and legal frameworks for the implementation (EPA/Ministry of Economic Development and Co-operation 1996, MoEDAC). It also deals with providing a strategic framework for integrating environmental planning into a new and existing policies and projects.

It mainly recognizes the importance of incorporating environmental factors into development activities from the beginning so that planners may take into account environmental protection as an essential component of economic, social and cultural development

3.3. The Environmental Policy of Ethiopia (EPE, 1997)

The policy provides a number of guiding principles that indicate and require a strong adherence to sustainable development, and a high commitment to, among other things, the need:

- To ensure that environmental impact assessments consider not only physical and biological impacts but also address social, socio-economic, political and cultural conditions;
- To ensure that public and private sector development programs and projects recognize any environmental impacts early and incorporate their containment into the development design process;

- To recognize that public consultation is an integral part of EIA and ensure that EIA procedures make provision for both an independent review and public comment before consideration by decision makers; and
- To ensure that an environmental impact assessment always includes mitigation plan for environmental management problems and contingency plans in case of accidents, This policy sets the scene for developments and projects within Ethiopia, particularly those of national significance. The policy underpins the regulatory requirements for EIA and pollution control and requires developers to aspire to the highest international standards of environmental and social management for project development.

3.4. The Investment Proclamation No. 37/1996

The proclamation provides the power of allocating land for investment operation to the regional governments. It lays down major framework for the use of rural land for natural resources development and conservation which may not be allocated for private investment especially on that of the peasant holding.

Furthermore, the provision of this proclamation states that the investors shall submit the development proposals on the land utilization plan by ensuring that the venture will not disrupt environmental security and shall be accepted to the public.

3.5. Ethiopian Water Resources Management Proclamation (Proclamation No.197/2000)

Article 11 of this proclamation states that without prejudice to the exceptions specified under Article 12 of this Proclamation, no person shall perform the following activities without having obtained a permit from the Supervising body (Ministry of water and Energy or delegated bodies): construct water works; supply water, whether for his own use or for others; transfer water which he/she abstracted from a water resource or received from another supplier; and release or discharge waste into water resources unless otherwise provided for in the regulations to be issued for the implementation of this Proclamation. Any person shall be required to discuss his/her proposal with the supervising body prior to applying/ for a permit for the purposes specified in Sub-Article (I) of this Article.

Article 12 states any person shall utilize water resources for the following purposes without holding a permit issued by the Supervising body: dig water wells by hand or use water from hand-dug wells;

use water for traditional irrigation, artisanal and for traditional animal rearing, as well as for water mills.

3.6. Labor proclamation (No. 377/2003)

This proclamation highly emphasizing that an employer should take the necessary measures to safeguard the health and safety of his workers. The employer shall in particular: comply with the occupational health and safety requirements provided for in this proclamation.

- Take appropriate steps to ensure that workers are properly instructed and notified about the hazards of their respective occupations and the precautions necessary to avoid accident and injury to health.

- Provide workers with protective equipment, clothing and other materials and instruct them of its use etc. In general, to ensure workers safety and job security the need to respect this proclamation has been clearly stated in the document.

3.7. Public health-proclamation (proc. No. 200/2000)

In addition to the occupational health and safety measures and precautions indicated in the labor laws, this public health proclamation underscores the need for avoiding machineries or instruments that can generate excessive noise or minimizing the effects by the use of noise reducing apparatus or instrument. In addition, the proclamation prohibits:

- The discharge of untreated liquid waste generated from septic tanks, seepage pits and industries into water bodies, or water convergences.
- The disposal of solid, liquid or any waste in a manner, which contaminates the environmental or affects the health of the society.

The proclamation establishes a system that enables coordinated but differentiated responsibilities among environmental protection agencies at Federal and Regional levels. The proclamation stipulates the need for the establishment of Sectoral and Regional Environmental Units and Agencies.

The principal organization responsible for environmental protection is the Environmental Protection Authority (EPA), which operates at both Federal and Regional levels.

3.8. Environmental Pollution Control Proclamation No. 300/2002

This Proclamation states "No Person or establishment shall pollute or cause any other person to pollute the environment by violating the relevant environmental standards." Environmental standards specified in the proclamation include:

- Standards for the discharge of effluents into water bodies and sewage systems;
- Air quality standards that specify the ambient air quality and give the allowable amounts of emission for both stationary and mobile air pollution sources;
- Standards for the types and amounts of substances that can be applied to the soil or be disposed of on or in it;
- Standards for noise providing for the maximum allowable noise level taking into account the settlement patterns and the availability of scientific and technological capacity in the county; and
- Waste management standards specifying the levels allowed and the methods to be used in the generation, handling, storage, treatment, transport and disposal of the various types of waste.

3.9. Solid Waste Management Proclamation No. 513/2007

The solid waste management proclamation stipulates, among others, that « Each Region or administration unit shall set its own schedule, and based on that, prepare its solid waste management plan and report implementation.

It further spells out that each administration unit shall ensure that measures are taken to prevent pollution from mishandling of solid wastes.

Similarly, existing institutional arrangements overseeing the environmental performance of the industry were summarized.

A waste management plan will be prepared during the detailed design stage of the Unit to mitigate the impacts through reduction in the use of consumable items, recycling of materials, and disposal of hazardous wastes at certified locations.

3.10. Hazardous Waste Management and Disposal Control (Proc. No.1090/2018)

Under Part two and sub section six of this document stated on Responsibility of Hazardous Waste Generator as follows.

Hazardous waste generator shall have the following responsibilities: Collect, segregate and dispose or cause to be collected, recycled or disposed of hazardous waste by authorized body; ensure that the

container of hazardous waste are properly packed and conspicuously labeled with Amharic and English languages; keep record on the type and quantity of hazardous waste that exist at the temporary hazardous waste storage facility; and show the record at any time when requested by inspector; not to store a hazardous waste at a temporary storage facility for a period exceeding one month.

Under Part two sub section seven stated on Labeling of Hazardous Waste as follows:-

Any hazardous waste generator, collector, transporter or importer shall conspicuously label the hazardous waste. The label of hazardous waste shall contain the following information:

a) Full address of the generator;

b) Type, quantity and characteristic of the hazardous waste;

C) Formal management and methods of management.

Any hazardous waste generator, collector, transporter or importer shall affix conspicuous warning or caution sign or text on the container in Amharic and English language or other languages of the country as may be necessary.

Under Part two sub section eight stated on transportation of Hazardous Waste as follows: Any person seeking to engage in the transportation of hazardous wastes shall obtain authorization from the Ministry. Where the applicant fulfills the requirements stipulated in the directives to be issued for this purpose, the Ministry shall issue the authorization within 30 working days; where the applicant fails to fulfill the requirements, he shall, notify in writing within 15 working days, either to submit additional document or the denial of the authorization. When the applicant is dissatisfied with the decision, he may submit his complaint to the Minister within 15 working days. Any transporter of hazardous waste shall transport the wastes in a manner that does not affect the human and animal health or the environment or reusability and subsequent treatment of the hazardous waste. Any person engaged in the transportation of hazardous waste shall train his drivers on the transportation and management of hazardous waste. Any institution engaged in the transportation of hazardous wastes shall ensure that the consignment is adequately insured to cover liability ensuing from any harm to human or animal health or the environment that may result from any accidental release. Anybody who infect and damage the environment, human and animal health during transportation, generation, collection and reusing, recycling, treating as well as disposing process of hazardous waste, shall pay compensation for damage according to the provisions of pollution proclamation issued. The authorization issued to any person pursuant to the provision of sub-article (1) of this Article shall be renewed every year up fulfilling the requirements stipulated in the directives issued for this purpose.

Under Part two sub section nine stated on documents accompanying transportation of Hazardous Waste as follows:- Any transporter of hazardous wastes shall be accompanied by a document issued by the Ministry during transportation: Without prejudice to sub-article (1) of this Article, the transporter shall accompany documents showing the following additional information:

a) Name, date and full address of the initial and final destination of the consignment;

b) Scientific and common names of the hazardous waste;

c) Number and type of packages as well as the total quantity;

d) Full addresses of the consignor and consignee;

e) Information on safety measures to be taken in case of an accident.

The transporter shall have a duty to show the documents mentioned in sub-article (2) of this Article at any time to the inspector assigned by responsible authority.

Under Part two sub section ten stated on precaution to be taken during transportation of Hazardous Waste as follows:- The driver who transports hazardous wastes, upon receiving the documents specified in Article 9, shall ensure that the consignment complies with the description contained in the documentation. Any hazardous wastes being transported shall be secured with load restraint to prevent movement or spilling of the load during travel. In the event of any accident during transportation of waste the driver shall take the following measures:

a) Secure the area around the vehicle and the spill;

b) Call emergency services;

c) Immediately notify to consignor, the consignee, and the responsible authority on the nature of the spill or accident.

Under Part two sub section eleven stated on Hazardous Waste storage as follows:-Any person seeking to engage in the storage of hazardous wastes shall obtain authorization from the Ministry. Upon receipt of any application to secure authorization, the Ministry shall ensure fulfillment of the following requirements: a) adequate facilities and other necessary equipment are available for the safe storage of hazardous wastes; b) availability of adequate security and health and safety equipment.

Without prejudice to the requirements stipulated under sub-article (2) of this Article, the Ministry, as may be necessary: a) prepare procedures and other prerequisites for the licensing of hazardous waste storage; b) issue requirements pertaining to the storage facilities of hazardous wastes in collaboration with the competent authority. The applicant to obtain authorization for storage of hazardous waste shall, before commencing operation, enter insurance to cover liability for harm to human or animal health or the environment. Where the applicant fulfills the requirements, the Ministry shall issue the

certificate within 30 working days; where the applicant fails to fulfill the requirements, he shall, within 15 working days, be notified in writing either to submit additional document or denial of the authorization. When the applicant is dissatisfied with the decision, he may submit his complaint to the Minister within 15 working days.

The authorization issued to any person pursuant to the provision of sub-article (1) of this Article shall be renewed every two years up fulfilling the requirements.

Under Part two sub section twelve stated on precaution to be taken Hazardous Waste storage as follows: Any owner or administrator of a storage facility shall: prevent the storage facility against unauthorized access; ensure that all hazardous wastes stored on the premises are packed, labeled and segregated; maintain data on the type, character and amount of any hazardous waste stored in the premise and ensure that the data are readily accessible to the inspectors; ensure that emergency equipment are readily available to contain an accidents; conduct daily inspection of the hazardous wastes stored on the premises by trained personnel to control the accidental release; place an indicator to the boundary of hazardous waste storage facility; ensure that the employees engaged in hazardous waste management has obtained appropriate training in the field.

Under Part two sub section thirteen stated on Re-use of Hazardous Waste as follows:-Hazardous wastes may be reused where it is proved that it does not cause harm to the human and animal health and environment.

Under Part two sub section fourteen stated on treating and recycling of Hazardous Waste as follows:-any person seeking to engage in the treating and recycling of hazardous wastes shall apply to the Ministry and obtain authorization. Any person submitted application to the Ministry pursuant to sub-article (1) of this Article shall be granted authorization when the fulfillments of the following preconditions are verified: Complies with the requirements of registration set in the directives of the Ministry; that the recycling facility and its processes are acquiescent in accordance with the requirements set by the Ministry; and put in place a process that disposes the hazardous wastes generated during the treating or recycling process in an environmentally sound manner. Where the applicant fulfills the requirements, the Ministry shall issue the authorization within 30 working days; where the applicant fails to fulfill the requirements, he shall, within 15 working days, be notified in writing either to submit additional document or denial of the authorization When the applicant is dissatisfied with the decision, he may submit his complaint to the Minister within 15 working days. The authorization issued to any person pursuant to the provision of sub-article (1) of this Article shall be renewed every two years up fulfilling the requirements.

Under Part two sub section fifteen stated on treatment and handling before treating and recycling of Hazardous Waste as follows:- During storage of hazardous waste, appropriate measures shall be taken to prevent the risks of breakage and potential exposure of substances of concern from improper handling. To prevent or minimize potential risks, the recycling facility shall ensure that employees engaged in hazardous waste recycling duty have obtained appropriate training in the field. Appropriate safety materials have to be fulfilled to ensure prevention of recycling and disposal facility employees. Any person who engaged in the treatment of hazardous waste must inform to the Minister, the type, quantity and way of treatment of hazardous waste.

Under Part two sub section sixteen stated Disposal Hazardous Waste as follows:-The hazardous wastes must be discharged, if it proved recycling of the waste is impossible even after treatment. Hazardous waste disposal activity shall be carried out according to hazardous waste proclamation

3.11. The Environmental Impact Assessment Proclamation No. 299/2002

The proclamation formalizes EIA as a mandatory legal prerequisite for the implementation of major development Units, programs and plans.

Environmental impact assessment is used to predict and manage the environmental effects that a proposed developmental activity could bring about some drawbacks and risks.

The design, sitting, construction, operation as a result of its modification or termination intends and thus helps to bring about intended development.

This proclamation is a proactive tool and a backbone to harmonizing and integrating environmental, economic, cultural, and social considerations into a decision making process in a manner that promotes sustainable development.

3.12. Regional/Oromia Proclamation (Proclamation No. 176/2012 and 177/2012)

The Oromia Regional state has established an "***Oromia Environment, Forest and Climate change Authority***" that has prime responsibility for ensuring sustainable development in the region. The authority has its branch offices in the administrative zones; woreda's and in twelve selected cities of the region. The twelve cities where the authority has branch offices consist of Adama, Bishoftu, Burayu, Gelan, Asela, Jimma, Legetafo, Sululta, Dukem, Shashemene and Nekemte. The Oromia regional state has adopted the Federal Proclamation on Environmental Impact Assessment and on pollution control, called 'Oromia National Regional state Environmental Impact Assessment Proclamation No. 176/2012' and 'Oromia National Regional state Environmental Pollution Control

Proclamation No.177/2012'. In addition to the framework proclamations, the authority is preparing detailed regulations on EIA and pollution control which are currently drafted and being discussed in house. Clearly the region has an environmental and social management system that requires for conducting EIAs for development projects. The enforcement of this requirement for environmental assessment is spearheaded by authority and its branch offices at Zonal, town and Woreda levels.

3.13. Regulations Pertaining To Standards

3.13.1. Effluent Standards

Ethiopia has provisional national standard governing effluent discharges from tanning industries. These draft guidelines require tanneries to meet certain basic water quality standards for tanning industries discharge to water bodies as shown in Table-1 below.

Table 4: Emission limits for effluent discharge to water bodies (Ethiopia Standard)

Parameter	Emission limit, mg/l
Temperature	40^0C
pH	6-9
BOD_5 at 20^0 C	>90% removal or 200 mg/l
COD	500
Suspended solids	50
Total ammonia as N	30
Total nitrogen as N	>80% removal or 60mg/l
Total phosphorous as P	>80% removal or 10mg/l
Oils, fats and grease	15
Mineral oil (interceptor)	20
Chromium as total Cr	2
Chromium as Cr(VI)	0.1
Chloride (as Cl^-)	1000
Sulfide	1
Phenols	1

The facility requires wastewater treatment system and therefore develops effluent treatment that conforms to national standards for wastewater discharges.

3.13.2. Noise Standards

Ethiopia has no national legislation for noise, but World Bank guidelines have been adopted by EPA and are used for benchmarking purposes along with the draft National Noise Standards that are being prepared. The guideline for daytime perimeter noise is 55 decibels (dBA). Table 2 provides noise standards being adopted by EPA for Ethiopia.

Table 5: Limit Values for Noise level

Area Code	Category of area	Limits in dBA	
		Day time[1]	Night time[2]
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45

3.13.3. Ambient Air quality Standards

Ethiopia has no national legislation for air quality, but World Bank guidelines have been adopted by the EPA and are used for benchmarking purposes along with the draft National air quality standards that are in preparation by the EPA. Table 3 provides the provisional air quality standards being adopted by EPA for Ethiopia as well the WB/IFC guidelines values.

Table 6: Limit Values for Emissions to Air

Pollutant	Units	Guideline values	
		Ethiopian standard	**WB standard**
Particulate Matter PM2.5	µg/Nm^3	None	30a[3]
Particulate Matter PM 10	µg/Nm^3	150	100
Sulphur dioxide (as SO_2)	µg/Nm^3	1000	400
Nitrous oxide (as NO_2)	µg/Nm^3	2000	600

3.13.4. Industry Standards and Codes of Conduct

A growing number of guidelines or codes of conduct have been developed within industry, including the World Industry Council for the Environment, the FAO International Code of Conduct on the

[1]Day time reckoned to be between 6.00 am to 9.00pm

[2] Night time reckoned to be between 9.00pm to 6.00am

[3] a 10 µg/Nm3 if more than 40 percent of the resulting heat comes from hazardous waste

Chemical Manufacturers Association and chemical users, the CERES/Valdez Principles, the ICC Business Charter on Sustainable Development, and the Royal Dutch/Shell Group Statement of General Business Principles. Such private regulation may constrain behaviour by exercising a moral or practical (sanctioning) influence. Litigants may argue that breach of such codes or industry standards may be evidence of malpractice or negligence, in an effort to deploy a relatively inexpensive means of evaluating conduct in case of a dispute. The 1990 Valdez Principles were adopted by the Coalition for Environmentally Responsible Economies, a group of investors and environmental organizations. The intent was to create corporate self-governance "that will maintain business practices consistent with the goals of sustaining our fragile environment for future generations, within a culture that respects all life and honours its independence."

With the advent of globalization, international organizations have devoted attention to drafting codes that apply to multinational enterprises. The UN Sub-Commission on Human Rights approved Norms on the Responsibilities of Transnational Corporations and Other Business Enterprises with Regard to Human Rights, urging that every effort be made so that they become generally known and respected. Although primarily concerned with human rights, the Norms contain a paragraph on corporate responsibilities in the area of environmental protection:

Transnational corporations and other business enterprises shall carry out their activities in accordance with national laws, regulations, administrative practices and policies relating to the preservation of the environment of the countries in which they operate, as well as in accordance with relevant international agreements, principles, objectives, responsibilities and standards with regard to the environment as well as human rights, public health and safety, bioethics and the precautionary principle, and shall generally conduct their activities in a manner contributing to the wider goal of sustainable development.

4. Description of the study

Tanneries convert animals hide and skin into leather through various processes. The raw material for the leather industry is the waste product from the slaughter house. The waste product, the skin of animals is being converted into useful end product called leather. Thus the leather industries relieve the disposal problem of uneatable hide and skins. Besides, the tanneries employee various cleaner production technologies and end of pipe treatment to reduce or curb the impact of their operation on the surrounding environment.

Modjo town is one of the most important destination of tanning industries. Currently, there are about 12 tanneries operational and contribute significantly (both positive and negative) to the town. In an obvious way, the industry contribute positively in creating significant job creation for local citizens and raise significant earning to government in the form of taxation. In addition the industry contribute significantly on the export earning taking the share of solving hard currency of the country. However, the operation of the industry generate significant solid, liquid and gaseous emission where the cumulative effect can be felt on the Modjo town environmental receptors like the river (Modjo river), ground water, land and other ecological and biosystem components. Therefore, this study aims to systematically analyze the impact of the operation of tanning industries in Modjo town and provide proper mitigation measures to minimize those impacts. Besides, the study also aims at devising a strategy to manage the solid waste generated from tanning industries.

4.1 General overview of Leather manufacturing process

Hides and skins are primarily composed of water, protein and fatty materials. The most important protein in the production of leather is collagen, which makes up approximately 29% of the mass of a freshly flayed hide. The collagen desirable for tanning is found in the grain and reticular layers where it is "intimately woven" in a three-dimensional mesh that is thick and tightly woven in the grain and coarser and stronger in the reticular layer. After slaughter, hides and skins must be temporarily preserved for shipment and storage prior to tanning. The most common commercial method of preservation is to cure the hides and skins using salt to produce a dehydrated wet-salted or dry-salted material. According to the report from leather industry development institute of Ethiopia the majority of leather (almost 90%) in Ethiopia is tanned with chromium and is therefore commonly used as the basic format when trying to understand leather production. Other methods of tanning will have significantly different production flow although if the material to be produced is

without hair, wool or scales, the preparation and isolation of the collagen in the beam-house processes will remain largely similar. The use of drums as process vessels but paddles, pits and mixers are also common. Leather manufacture is usually divided into three or four zones but this may vary slightly according to processing and the perspective from which it is viewed.

1. Preparation of the Raw Pelt for Tanning

Tanning primarily involves the reaction of tanning chemicals with collagen; raw hides contain a number of undesirable components, which are commonly removed prior to tanning. Approximately 75% of the mass purchased as raw material is removed as polluting solid or liquid waste. Preparation of the raw pelt includes the processes from soaking to pickling.

2. Soaking

Soaking is usually the first process encountered in the tannery, as the previously dehydrated raw material must be carefully rehydrated before it can be subjected to extended mechanical action. Water is also the vehicle for both chemical penetration and removal, and is a necessary prerequisite for most of the processes to follow. Soaking also assists in the removal of curing agents, non-structural proteins and fats. The flesh layer is removed mechanically to aid an even and full penetration of the chemicals to follow. Fleshing is commonly done after slaughter, after soaking, or after liming.

3. Unhairing and Liming

The majority of leathers produced are treated in order to remove the hair or wool to leave the characteristic pattern of the grain surface (analogous to wood grain). Conventionally, the hides or skins are treated with sodium sulphide and hydrated lime to destroy the keratinous material of the epidermis and hair or wool. Fats are hydrolyzed due to the increased pH and the skin structure swells as water is drawn into the fiber network to form a turgid, open-structured, translucent, jelly-like material.

4. Deliming and Bating

Weak acids are used to lower the pH and to reduce swelling which causes the water to flush out any impurities with it. The skin becomes flaccid and is treated with proteolytic bating enzymes to clean the grain and make the pelt smooth and silky.

5. **Pickling**

The bated pelts are finally treated with acid (commonly sulphuric and/or formic acid) to obtain the desired pH for optimal penetration of the tanning agent, and with salt, to suppress swelling when the acid is added. At this stage, the isolated collagen, termed the pickled pelt, is ready for a pretannage or man tannage.

6. Pretanning, Tanning and Retanning: This includes processes from Pretanning and tanning through to retaining via samming, splitting, shaving and neutralisation as a preparation for the dyehouse.

6.1 Pretanning

The pickled pelt may be lightly tanned prior to the main tannage to improve the penetration and distribution of the tanning chemicals to follow, to add specific properties into the leather or to stabilize it for mechanical operations such as shaving.

6.2 Mechanical Operations

At some point during production, the leather is split longitudinally to yield an upper grain split and a lower flesh split of desired thickness. In the production of chromium tanned leathers, this process is most commonly performed after basification and samming. The material is then shaved to give a more accurate and even thickness depending on the requirements for the end products e.g. shoe upper (1.8 mm), garment (0.9 mm) or upholstery leathers (1.1 mm).

6.3 Neutralization

The mechanical operations generally squeeze water out of the leather, so prior to further treatment a wetting back and washing process is used to rehydrate the leather and to remove dirt, shavings or grease that may have been picked up. The majority of the chemicals still to be added to the leather are anionic in nature, whereas the tanned collagen at low pH tends to be cationic in nature. Neutralisation is a process in which the pH is raised and chemicals are added to reduce the stringency of the leather to anionic chemicals such as retanning agents, dyes and fatliquors.

6.4 Retanning

The tanned leather is subjected to additional tannages with similar or new tanning materials. These agents may be used to lighten the colour of the leather, to produce a feeling of fullness and to aid in the penetration of dyes. The choice of Pretanning, tanning and retanning chemicals is dependent on the properties desired in the final leather, and therefore, on the properties required in the final leather product.

7. Dyeing, Fat liquoring and drying: This stage includes preparing the retanned material for finishing by processing through to dried crust.

7.1 Dyeing

Chromium tanned leather is blue in colour and must be dyed to obtain the desired colour. The dye acts as a base colour for finishing, and the depth of dye penetration and leather colour are of great importance.

7.2 Fat liquoring

Chromium tanned material dries out hard and crusty and is unsuitable for most purposes. Small quantities of oil, present as emulsions known as fat liquors, make a significant difference to the handle, i.e. the fullness, softness and flexibility, among other factors.

7.3 Drying

The retanning, dyeing and fat liquoring chemicals are allowed to penetrate and distribute within the collagen fiber structure before the pH is lowered and the astringency causes them to "fix" to the tanned material. The final binding of chemicals is encouraged by the drying process. Batches of leather are commonly toggle dried on frames in heated tunnels for four to six hours or are vacuum dried individually for two to ten minutes. Drying is usually followed by buffing, conditioning and staking or milling. The resultant curst material is resistant to microbial attack and contains all the leathering properties desired of leather and is ready for finishing.

7.4 Finishing

A finish process and finishing chemical must be carefully designed and "married" with the production of the curst to ensure compatibility. The finish may be required to hide defects, to contribute to the leather beauty and properties and to provide fashion effects. Resins, pigments,

dyes, handle modifiers, fillers, dullers and other chemicals are added in layers to the surface of the leather by spraying, roller-coating, curtain-coating or by hand. Heated hydraulic or roller presses are used to produce smooth or patterned leathers, depending on customer requirements. Finishing finally completes the leather manufacturing process and the area is then measured and the leather sent for dispatch to a product manufacturer to be turned into shoes, clothing or upholstery. The conventional process flow diagram and typical wastes produced at different stages of unit operations of leather manufacturing are depicted in Figures 1 and 2.

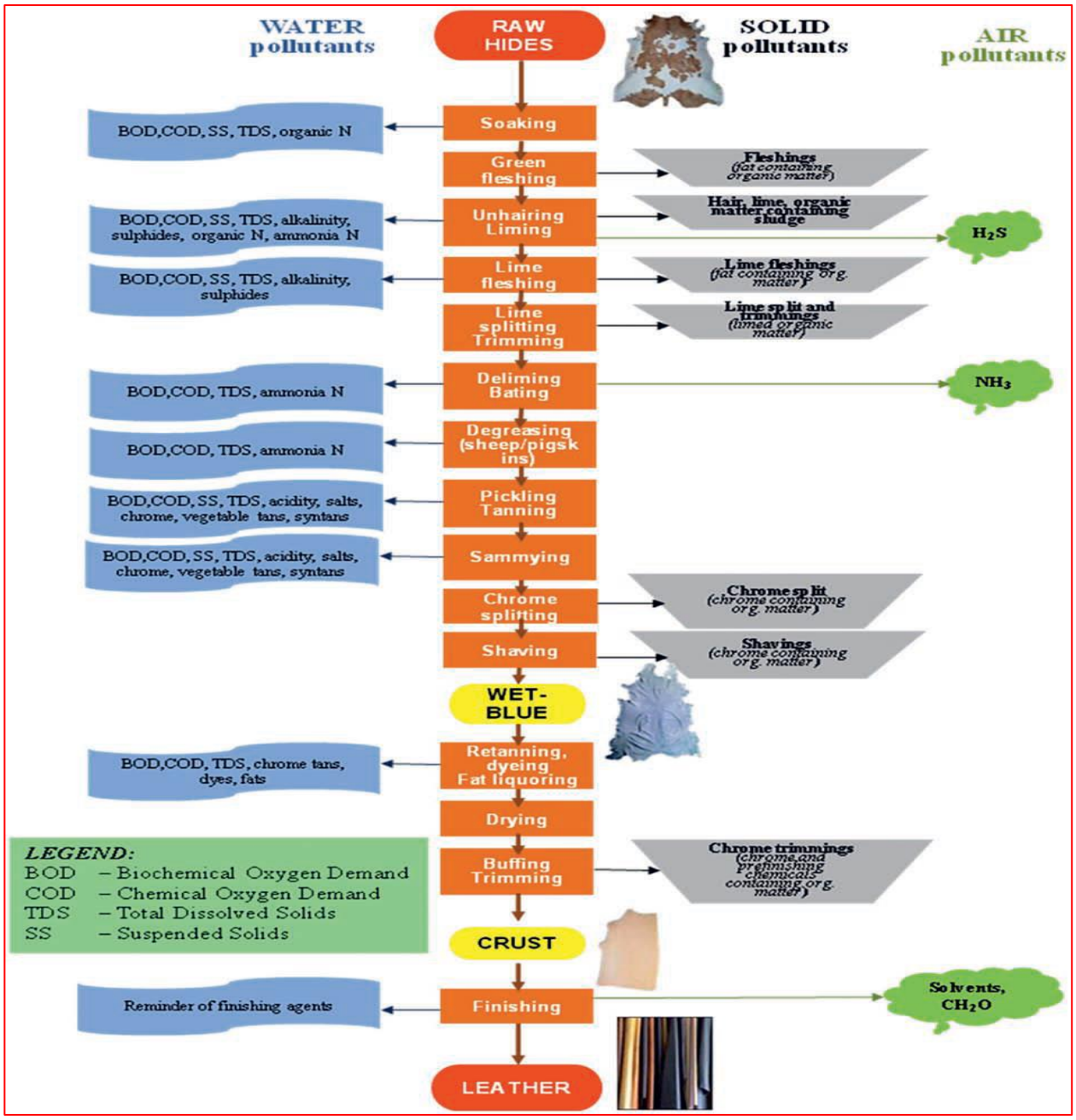

Figure 1: Sources and Types of pollutants generated in leather processing(*Source: UNIDO (2011))*

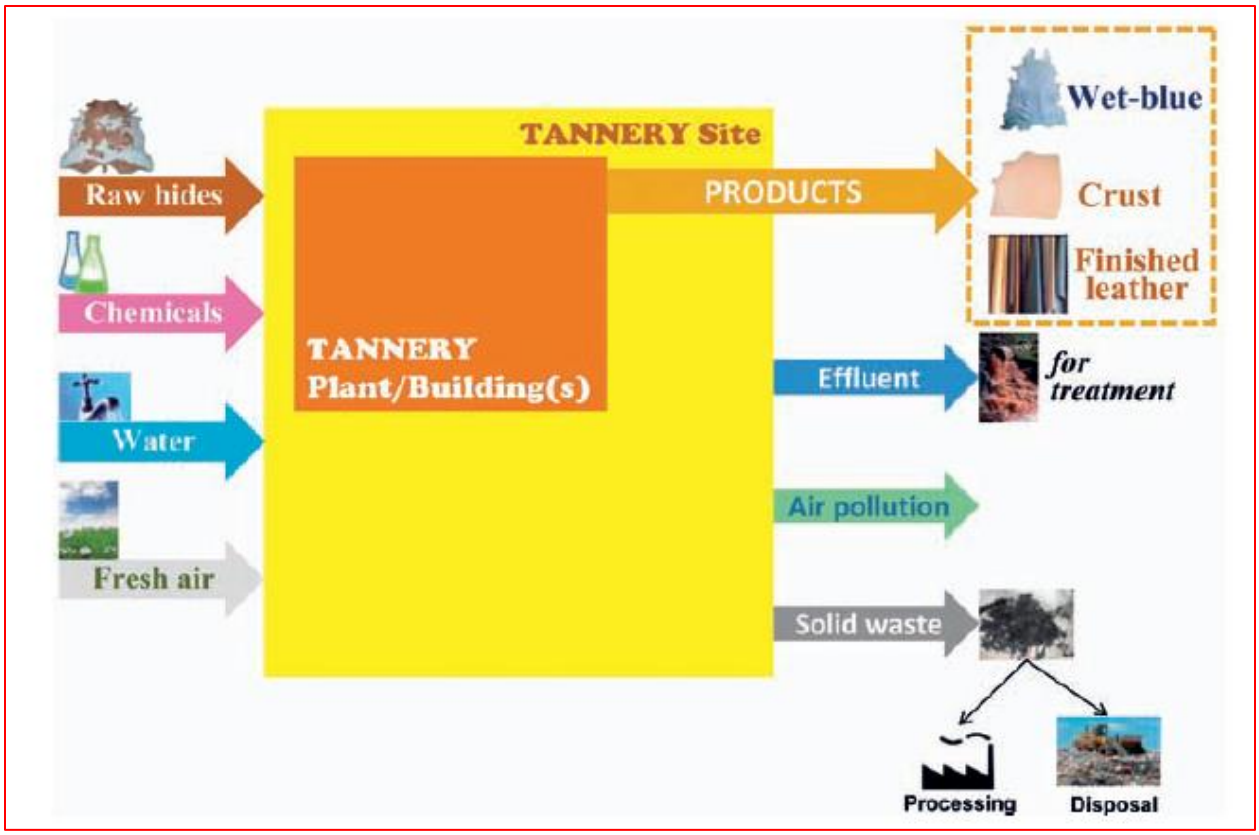

Figure 2: General overview of tanning industry (*Source: UNIDO (2011))*

5. Baseline Information of the Project

Environment means surroundings, which are comprised by living things and physical conditions. Those pertaining to the tanning industries have both bio-physical and socio-cultural aspects. Prior to detail description of the tannery location, a general description of the study area is presented in the subsequent topics and subtopics. The study area; when we mean, comprises the tanning industries and all surrounding areas that will be under significant influence, i.e., where the environmental impacts of the tanning operation can be felt (particularly the direct one).

5.1 Brief Description of the Study Area and its Physical Environment

As indicated in previous chapter, the cluster of tanneries is located in Oromia National Regional State, in Lume District primarily in Modjo town (Figure 4). It is nearly about 70 km from Addis Ababa and found on the eastern part of Ethiopia.

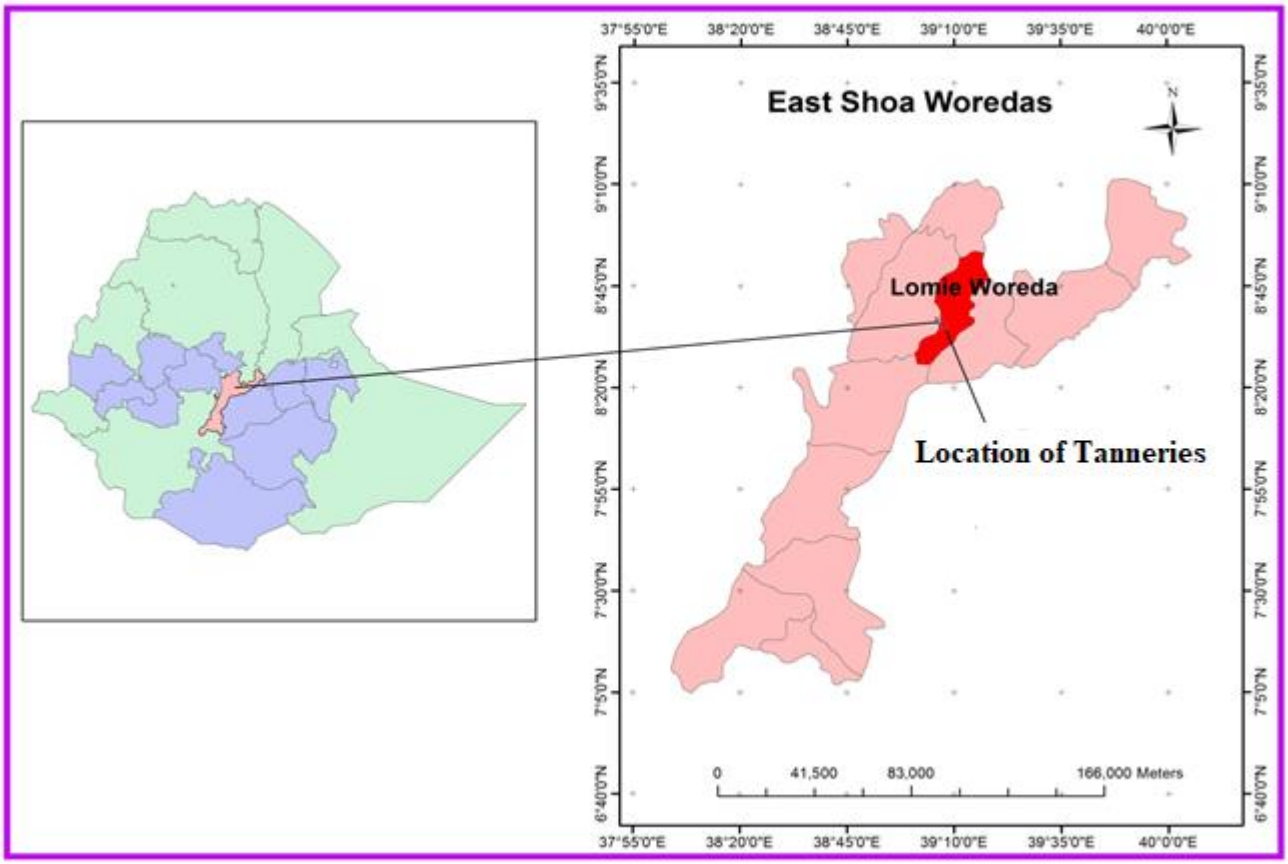

Figure 3: General location of the tanneries (Source: Lume Woreda Profile, 2019)

Lume district extends between $8^0$12’ -$8^0$50’ N and $39^0$01’ -$39^0$17’ E’ longitudes. It is located in the northern part of East Shewa zone. It is bordered with Ada Liben district in the west; by Gimbichu district in the north; by Adama district in East; and Dugda Bora district in south. Because of geographical location (i.e. near to the primate city Addis Ababa and three roads that leading to south and east part of the country & coming to Addis Ababa do radiate through) the district has a great advantage for accessing the local products to the market and creates ideal condition for provision of the demanded commodities to the local communities. Currently Mojo town has areas devoted to industrial zone and considered as industrial town. Lume district has a total surface area of 730 km^2. Mojo is the capital town of the district.

Modjo town is one of the town in and it is located in East Shewa Zone encircled by the Lume Woreda villages and by North Arifata and Jogola, South Kuruma Fatollee, East kolba Gode in West Tafi Abo and Dibandiba /shara Villages of farmers and in 2007 new master plane was prepared .So the location of Mojo towen are expanded in four (4) direction. From 1997 to 2011 the town expands form 1850 hectares to 2682 hectares .While, currently the town is about 5161.185 hectares.

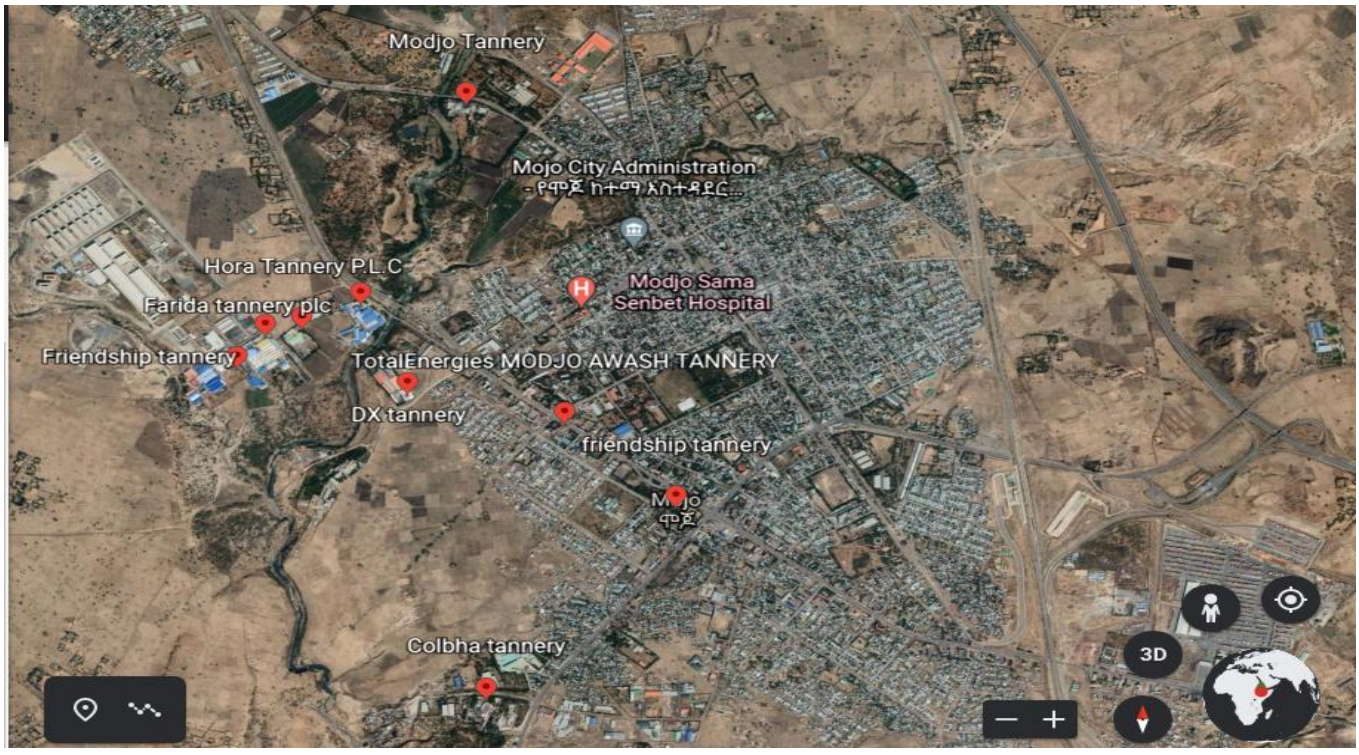

Figure 4: Location of tanneries found in Modjo town Administration (Source: Google earth map)

5.1.1. Physical Environment

Topography

The topographic condition of the tanneries location can be expressed based on qualitative and actual value (quantitative) based. The qualitative approach describes the tannings site's relative topographic feature with respect to the local topographic condition. Geological surveys indicated that the district is fallen under the quaternary volcanic or basalt that makes its conducive for farming activities, extraction of construction and industrial materials. Minerals occurring in the district include sand, ignimbrite, basalt, scoria, pumice, etc. Hence, mining practice is restricted to these mineral occurrences. The present land configuration of the Lume district is the result of past tectonic and denudation activities .The relief feature of the district is dominated by flat land that broken by hills, undulating and rolling plateaus. There are two major landform categories: the southern part that constitutes 70% parts of the district relief elevation ranges between 1500-2000 m.a.s.l. is mainly flat plains; while the northern part that lies between 2000 and 2500 meters (30%) is dominated by hills & undulating topography. There are also smaller hills that scattered over district.

Land use and land cover

There is no major erosion problem or land slide observed along the tanning areas. This green canopy of the tanning site has the inherent capacity to absorb pollution, increase water retention by soil and decrease sediment transport. In order to combat different kind of pollutions and avoid land slips from the portion of catchment draining directly into rivers and low lands.

Climate

Ethiopia located between 3^{o} and 15^{o} north latitude is characterized by monsoonal climate consisting well defined dry and wet season in most parts. The rainfall distribution in Ethiopia is explained in reference to the position of the Inter Tropical Convergence Zone (ITCZ). This zone is often traceable in May and November in Ethiopia. Broadly speaking, moist conditions prevail equator ward and dry conditions pole ward of the ITCZ (Gemechu, 1977). Local climatic conditions are

mainly controlled by variation in topography. Accordingly most part of the country falls in either of the three climatic zones. Dega (cool climatic zone) with an elevation of above 2440 m.a.s.l; Woina dega (warm climatic zone) with an elevation between 1830 to 2440 m.a.m.s.l and Kola (hot climatic zone) less than 1830 m.a.m.sl (Ethiopian treasures, 2014).The main Ethiopian rift, where the tanning industries are located is part, is characterized by dry weather through November to February mainly controlled by northeast winds. During this time the cloud is dry, humidity is low and diurnal temperature is high.

Between March and May high rainfall is experienced south of 6.30^{o} latitude, in the northern part light rain is received. The rainy months which are mainly controlled by the position of the low pressure inter tropical convergence zone (ITCZ) occurs from July to October as a result of convergence of warm wet air coming from Indian and Atlantic ocean and converging on the Ethiopian High lands (http://ilri.org/infoserv/Webpub/fulldocs/Bulletin17/environment.htm). The tannery cluster area is near Mojo town at 70 km south of Addis Ababa. The climatic condition is characteristic of the main Ethiopian rift. The area can be grouped in the hot climatic zone (Kola).

Rainfall

Ethiopia has an uplifted topography as compared to other parts east Africa. From this reason it is appropriate to assume that the uplift of the vapour laden maritime air and the subsequent rainfall to be caused by the topography resulting in an *orographic rainfall* than frontal or cyclonic while convectional storms may be important in a localised areas. The study area as most part of the main Ethiopian rift shows one dry season and one rainy season with. The annual rainfall near the study area is about 919 mm as estimated from FAO local climate estimator. The basin rainfall as calculated by using Thiessen polygon method is 968 mm. The dry season extends from October to February whereas the rainy season extends from March to September. The main rainy months are between June and September contributing about 73 % of the total rainfall. Highest rainfalls are received on July and August constituting about 50 % of the annual rainfall.

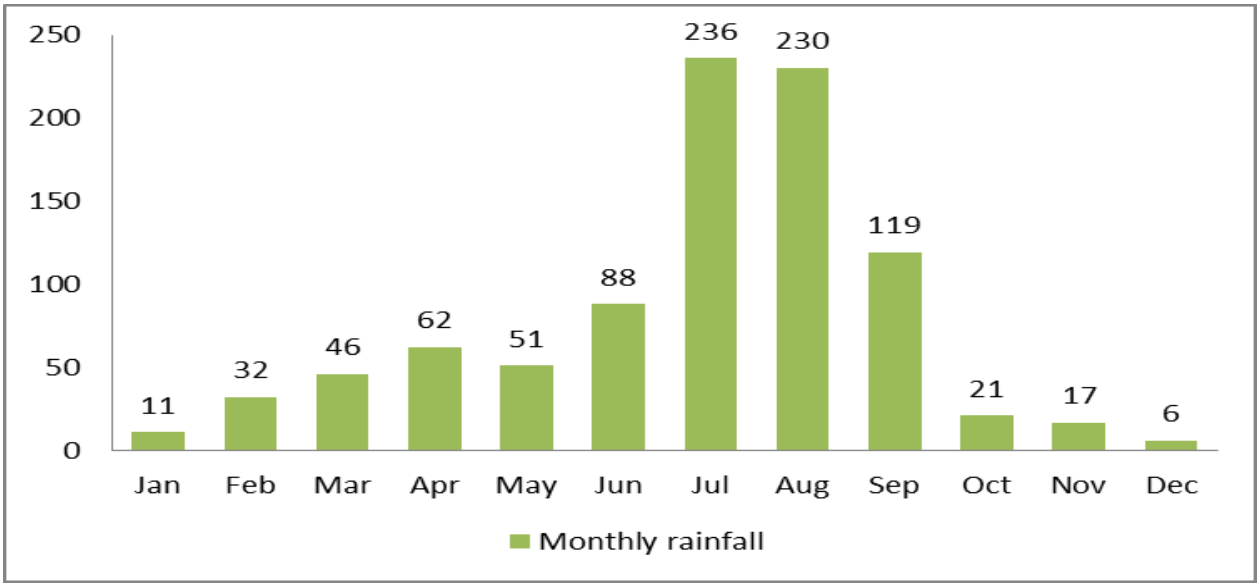

Figure 5: Monthly rainfall, mm (Source: General Profile of Modjo Town, 2019)

Temperature, humidity, wind speed and sunshine hour

Temperature

The mean minimum temperature in the tanning arears ranges from 10.5°C in the month of December to 14.8 °C in the month of June. The mean maximum temperature ranges from 22.2 °C in the month of December to 30.2 °C in the month of May. The mean temperature ranges from 16.3 °C in the month of December to 22.3 in the month of April.

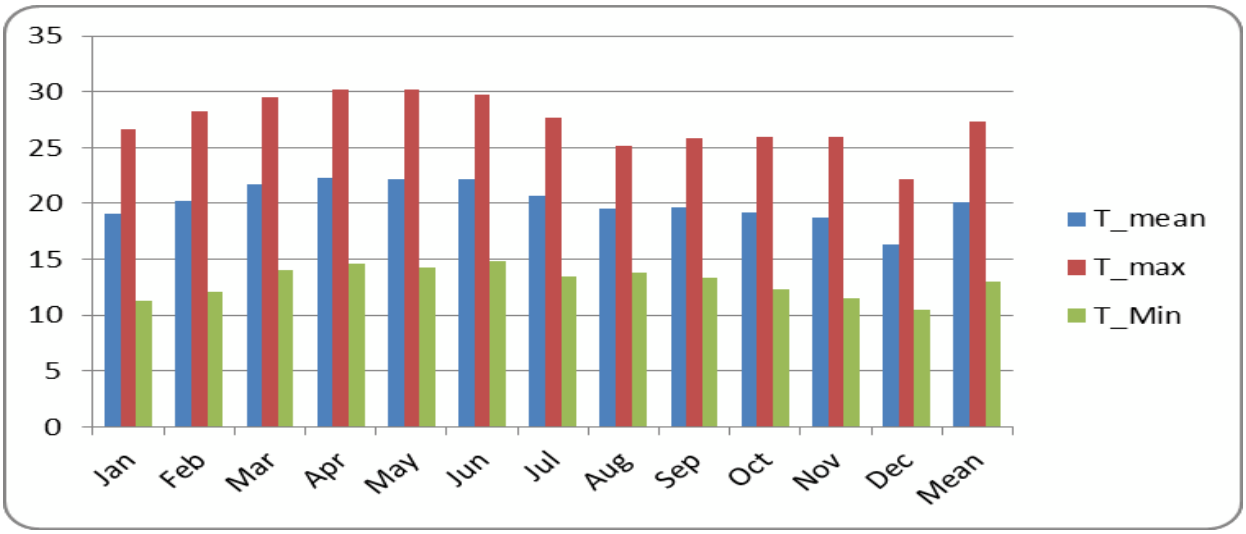

Figure 6: Mean maximum and minimum temperature,^{O}c, (Source: General Profile of Modjo Town, 2019)

Humidity

The moisture content of air, expressed in weight per unit of volume is called the absolute humidity. But for most practical purposes the relative humidity is taken into consideration. The monthly relative humidity in this station is tabulated as follows. The high relative humidity months coincide with the rainy months whereas the low humidity months coincide with the dry months. The Relative humidity ranges from 62.4 % in the month of October to 76.7 % in the month of August.

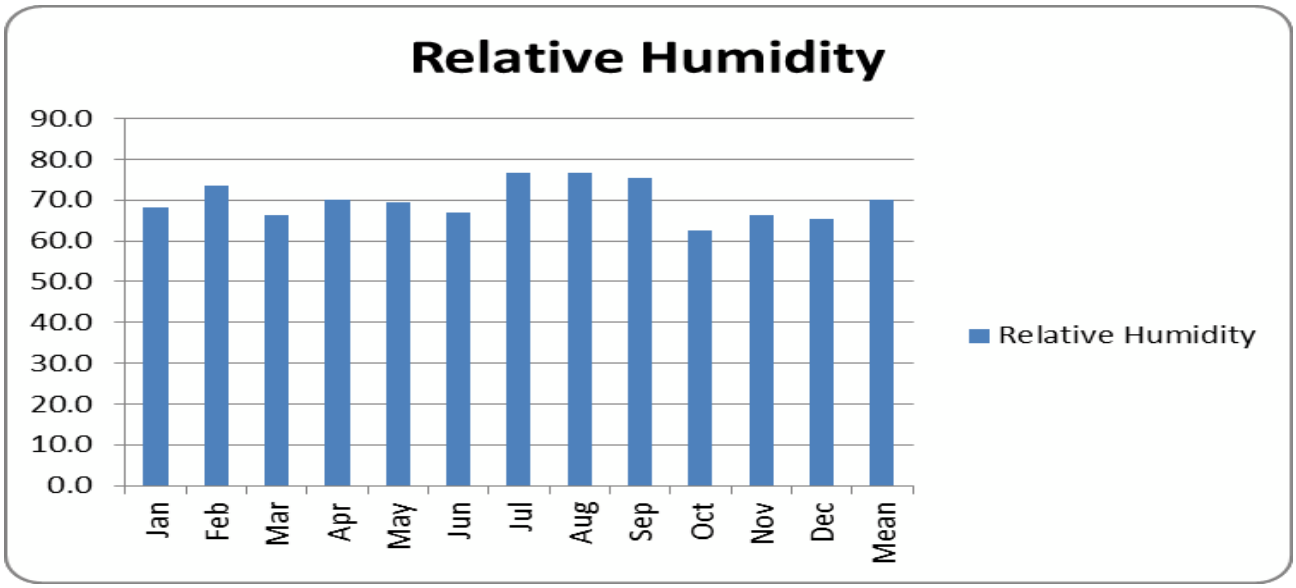

Figure 7: Relative humidity, % (Source: General Profile of Modjo Town, 2019)

Wind speed

Wind speed has a strong influence on the principal hydrological elements such as evaporation. The wind speed at elevation of 2 meter above the surface was measured around the tanning areas. It ranges from 2.88 km/h in September to 7.92 in December. The impact of wind on the area is important as is responsible for transport of dust particles and bad odor.

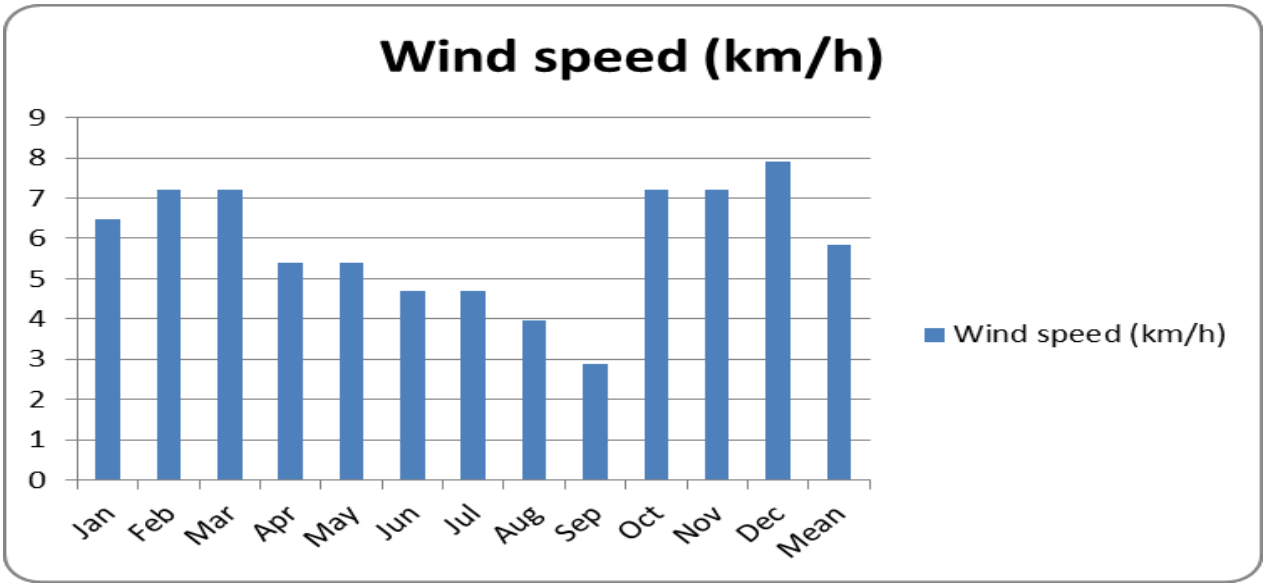

Figure 8: Wind speed,km/hr (Source: General Profile of Modjo Town, 2019)

Sunshine hours

The daily sunshine hours determines the amount of solar radiation received on a given surface area. On the proposed area the sunshine hour ranges from 6.41 in August to 9.01 in November.

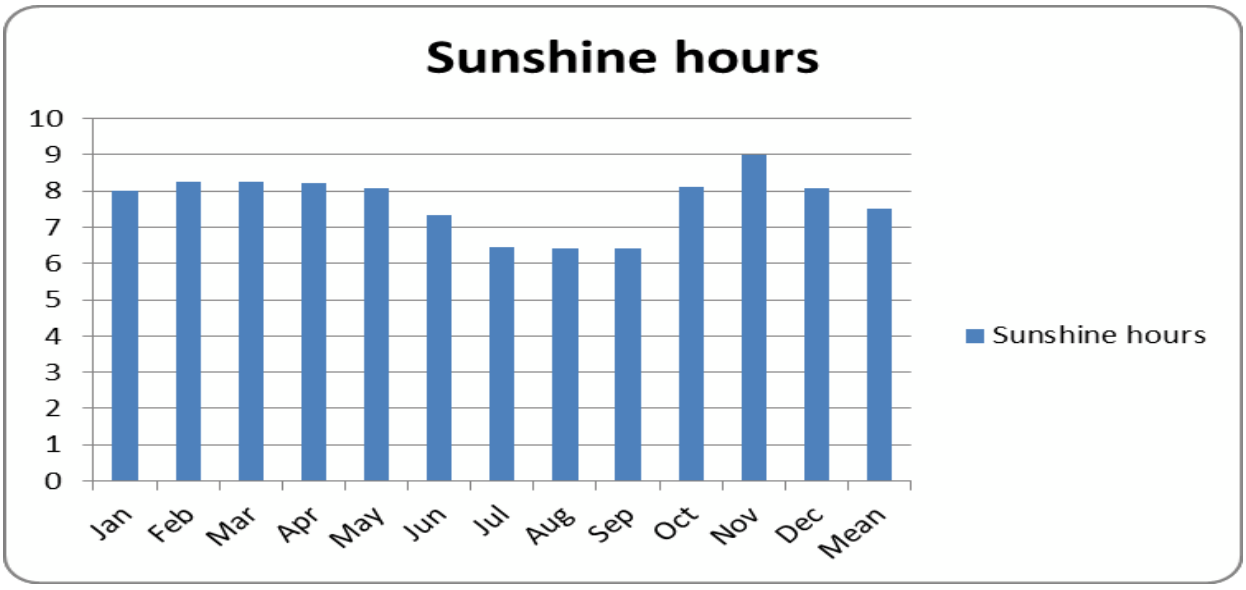

Figure 9: Sunshine hours (Source: General Profile of Modjo Town, 2019)

Table 7: Summary of various elements in months

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	11	32	46	62	51	88	236	230	119	21	17	6
T_mean	19.1	20.2	21.7	22.3	22.2	22.2	20.7	19.5	19.6	19.2	18.7	16.3
T_max	26.7	28.3	29.5	30.2	30.2	29.7	27.7	25.2	25.8	26	26	22.2
T_Min	11.3	12.1	14	14.6	14.3	14.8	13.5	13.8	13.3	12.3	11.5	10.5
Sunshine	8.02	8.24	8.26	8.21	8.07	7.33	6.46	6.41	6.41	8.13	9.01	8.07
wind [km/h]	6.48	7.2	7.2	5.4	5.4	4.68	4.68	3.96	2.88	7.2	7.2	7.92
Relative humidity	68.25	73.46	66.22	70.15	69.46	66.8	76.6	76.71	75.36	62.44	66.27	65.25

(Source: General Profile of Modjo Town, 2019)

Water resource

Ethiopia has 12 river basins with an annual runoff volume of 122 billion m^3 of water and an estimated 36 billion m^3 of ground water potential. This corresponds to an average of 1,575 m^3 of physically available water per person per year, a relatively large volume. However, due to large spatial and temporal variations in rainfall and lack of storage, water is often not available where and when needed. Only about 3% of water resources are used, of which only about 11% (0.3% of the total) is used for domestic water supply (Kebede, 2013).

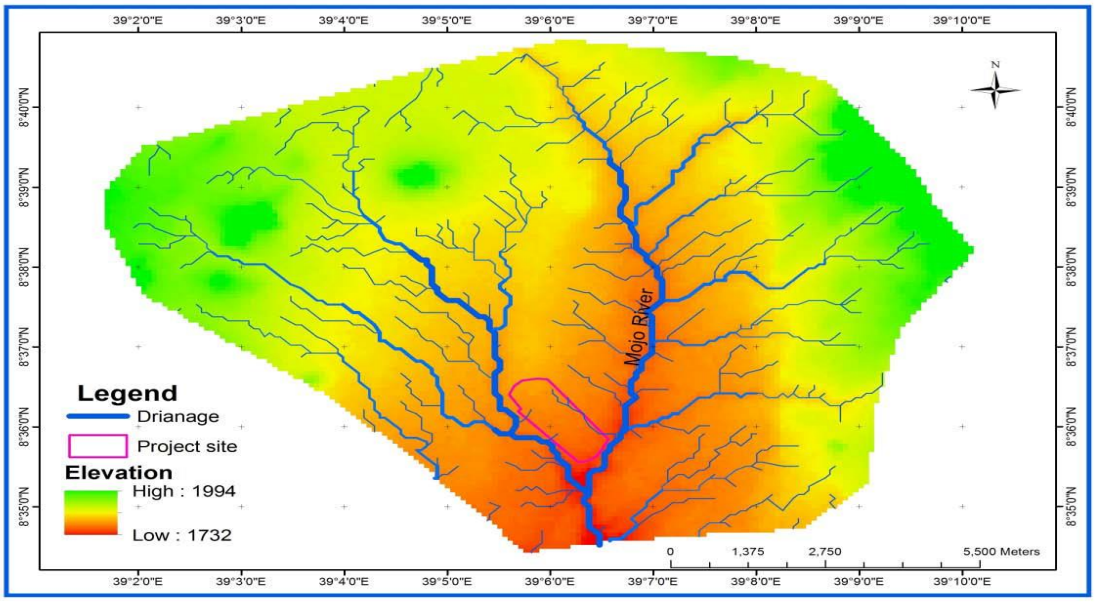

Figure 10: Drainage of the tanning area (Source: Kebede, 2013)

Surface water resources of the study area

The area is part of the Awash basin. The major river in the tanning area is Mojo River which flows into Koka reservoir. Modjo River is a perennial river with a mean flow of about 12.08 m^3/sec and catchment area of about 1600 km^2. Most of the flow occurs from June to September, which accounts about 85% of the total flow. The basin annual rainfall estimated from data of five meteorological stations distributed throughout the catchment is about 968 mm (Berhanu, 2007). The available stream water near Mojo is about 379 MCM per year which is equivalent to 24.5 % of the basin rainfall. The usability of this river water is strongly hampered by its quality downstream of Mojo town.

Table 8 : Surface discharge in months

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Discharge (m^3/sec)	0.80	1.11	1.15	2.12	2.70	6.60	33.86	64.71	27.48	2.20	0.80	0.73

Groundwater resource of the study area

The groundwater resource potential of a given area is dependent on the geological condition, geomorphologic situation and rainfall amount. The area is characterized by ash flows, unwelded tuffs and Rhyolitic ignimbrite (Low permeability groups), Lacustrine deposits, Bedded Tuffs (Moderate permeability group) and highly fractured Basalt and ignimbrite (High permeability group). Gemorphologically the tanning area comprises the lower reach of Modjo River signifying a discharge zone where by significant amount of groundwater resource is expected. The recharge amount in the whole Modjo basin is estimated to be 190 MCM/ year. The current groundwater use in the basin is not more than 4 MCM (Berhanu, 2007). This implies that the groundwater resource is underutilized.

Water quality assessment

The usability of water for drinking, irrigation and industry is linked to its chemical and biological quality. In situ measurement of electrical conductivity, pH, and temperature of surface water, shallow groundwater and deep groundwater has been conducted on the tanning area. Moreover

samples have been collected from the different sources (Modjo river upper and lower catchment, ground water from tanneries) and sent to laboratory (Leather Industry Development Institute and Addis Ababa Water and Sewerage Authority) for further analysis. As per the field result the electrical conductivity increases as one goes from upstream to downstream along the Modjo River. It changes from 337 μs /cm to 588 μs/cm within 5 km interval indicating the influence of existing industries and municipal waste on the day September 29, 2021.The pH is higher in the river water than in the groundwater. The pH value of Mojo River at downstream is relatively high indicating the impact of the effluents from the tannery industries. During ground water sampling from East Africa tannery, CODE 7 shows unexpected results deviation from the ground water scenario, and later the consultant decides to repeat sampling and analysis, CODE 8 which is more representative of the ground water.

Table 9: Results of the water sample from Modjo River and Tanneries located in Modjo areas during September 29, 2021

Sample Point	Northing	Easting	Elevation	EC	TDS	pH	Temp	Remark
Modjo River Upper Catchment	$8^0$36’43’’	$39^0$06’52’’	1765	337	154	7.6	25.8	Modjo River upstream before receiving any industrial waste
Modjo River lower Catchment	$8^0$33’23’’	$39^0$05’46’’	1708	588	268	8.4	26.7	Modjo river after receiving effluent and municipal waste
Ground water (CODE 6)	$8^0$36’30’’	$39^0$07’00’’	1777	1821	898	7.1	-	Modjo Tannery Sh.Co. bore hole
Ground water (CODE 7)	$8^0$35’44’’	$39^0$06’41’’	1764	7770	4180	7.02	-	East Africa Tannery PLC bore 1
Ground water (CODE 8)	$8^0$35’44’’	$39^0$06’41’’	1764	1344	651	7.07	-	East Africa Tannery PLC bore 2

Figure 11 Pictures taken during sample collection from Modjo River (upper and lower catchment)

Soils

The area is characterized by cambisols and vertisols. The cambisols cover the northern and central parts of the Mojo river basin, whereas the vertisols cover eastern, western and southern portion of the basin. The dominant textural class for the top soil is light clay. Very small portion of the area mainly in the extreme east and west is covered by luvisols with a sandy clay loam texture.

Landscape and Topography

The topographic elevation of the town of Modjo ranges from 1890 M.a.s.l. to 1730 m.a.s.l. in the northern part of the town the area has high elevation when compared with the other part of the town i.e. Arifata & Gode area.This site is quarried for scoria. The Southern part of the town is the area around the high way towards Shashamane. From this high way the general characteristics of the Land is decreasing in elevation towards the West i.e. towards Modjo River. On the other hand the south eastern part of the town is ascending in elevation around Ethiopian Road authority comp. in western part of the town the topographic nature of the land is plain and almost uniform in elevation except in gorges of Modjo River where the land is descending.

The control part of the town is also almost plain. In the Eastern direction the topography is plain but in peripheral areas the land is ascending in elevation from Malke- Lemi towards Xadde high land.

Hydrology and major geological units

The rift area is one of extensively studied area from geological point of view. Several workers including (Kazmin, 1997, Damte, 1990, etc.) have explained very well the tectonics and lithology of the area. Generally the rocks in Modjo river basin can be grouped into two based on origin: Volcanic rocks associated with the quaternary volcanic activities covering 70% of the basin and volcano sedimentary rocks covering 30 % of the study area. For this purpose the major lithologies of the area will be outlined as described by Behailu (2007).

Recent to sub recent Rhyolite domes and flows

Covers a small part of the tanning area and it is found in the central part intercalated within the Bofa basalt. This unit is compact, porphyritic rhyolitic lava flow described as the remnant wall of the volcano tectonic sub-circular collapse of the Pleistocene age (Berehane et al, 1978).

Tulu Rie Basalt (TRB)

Tulu Rie Basalt crops out in the southeastern section of the town. The unit belongs to intra Rift complex where it covers the Nazret unit and forms the upper part of NE trending escarpments.

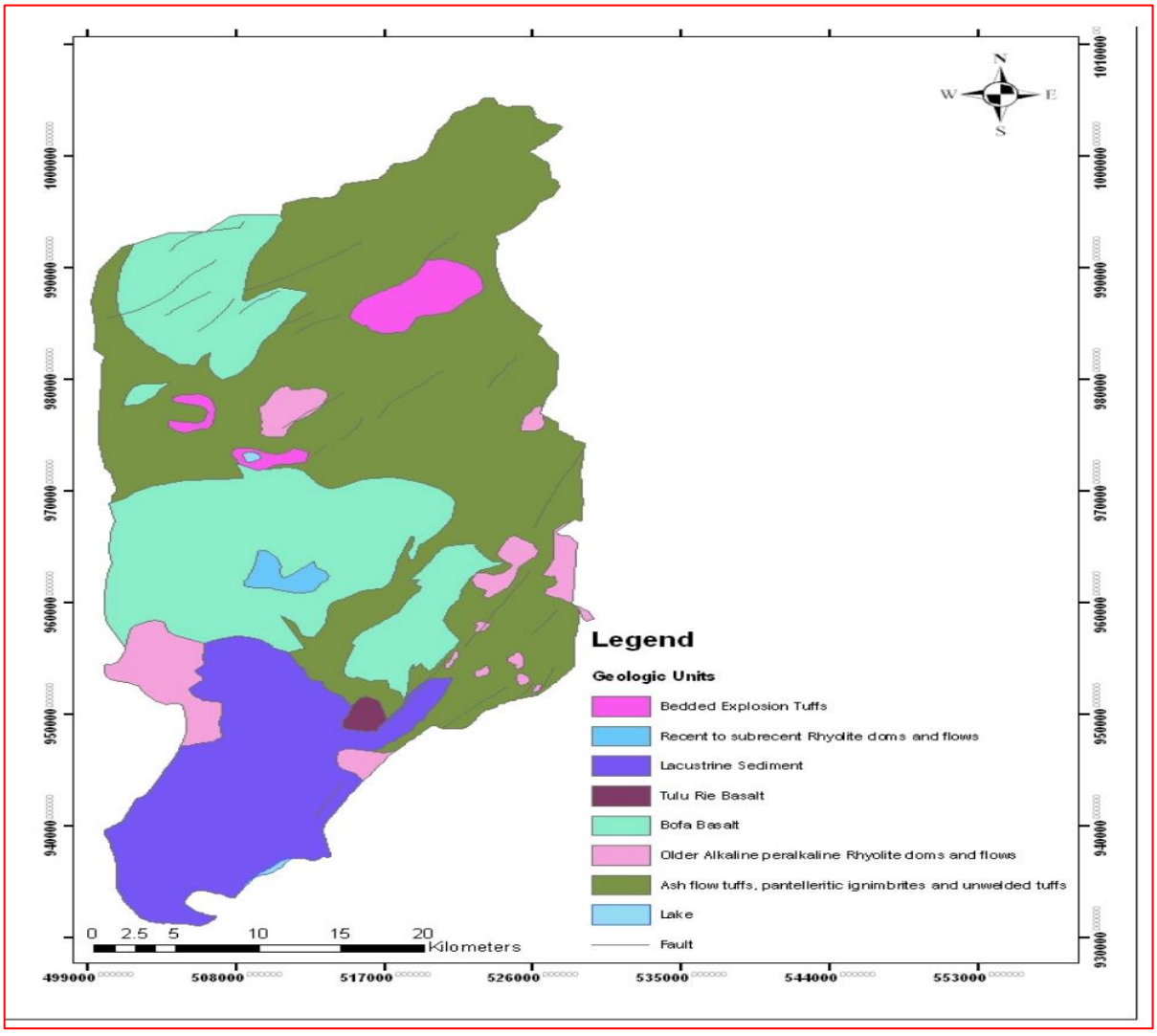

Figure 12: Geological units (Source: Berehane et al, 1978)

Lavas have mainly olivine basaltic composition, and rare plagioclase–rich basaltic andesites are also found. The basalts show porphyritic texture, the phenocrysts are generally constituted by olivine. The age ranges between 2.7-1.8 Ma. The Tulu Rie Basalt is considered, for its stratigraphic position and composition, as a part of Bofa Basalt of Kazmin and Seifemichael Berhe (1978). The TRB consists of sub horizontal or slightly tilted tabular lava flows. The maximum observed thickness is 20m at Tulu Rie Basaltic ridge at the southeastern catchment.

Bofa basalts

It is found on the northern, western and central parts of the town. The assemblages of the unit are mainly olivine, clinopyroxene, apatite and rare plagioclase–rich basaltic andesites are also found (Yirgu, 1980). The basalts show porphyritic texture is vesicular, less weathered and friable.

Ignimbrites

It is grayish red in color, moderately to highly weathered rock with medium to coarse grained having a kind of sheet flow structures. This unit is a basal unit grouped under the intra Rift complex and may constitute the upper part of Nazret Group of Kazmin and Seifemichael Berhe (1978).

Ash flows and welded tuffs

The ash flows are exposed in the study area forming a thin layer of 2-30cm thick intercalation of continuous horizontal layering. And are greenish gray in color. The fine grained compacted welded tuffs are less weathered at the bottom and highly weathered at the top with secondary fillings.

Lacustrine deposits and alluvial cover

The lacustrine beds are interbedded with Pliocene-Pleistocene ignimbrite in lakes region and on the rift shoulders in general and in Mojo and its surroundings in particular (Mohr, 1962). They are mostly reworked volcanic sands, siltstone, sandstone, calcareous materials and diatomite with intercalation of water-laid tuffs. The deposition is found on the closest vicinity of Lake Koka, lake Hora, and Lake Kilole. They represent about 30% of the exposed rocks in the basin and are developed on a relative NE longated depression in the central sector of the area. These deposits are generally brown-yellowish in color, fine to medium grained in texture, thinly stratified, very friable, and less compacted.

Hydrology

Hydrology deals with the origin, distribution and circulation of water in different forms in land phases and atmosphere (K.C. Patra, 2001). So basically it is treating the different hydro-meteorological elements of the hydrologic cycle either for water resource estimation or detailed investigation on each element and their interrelationship. In this chapter the interrelationship of the hydro meteorological elements through water balance is described.

Among other things water balance, which is the relationship between inflow, outflow and change in storage of water for a given water body or catchment, has been used for the prediction of stream flow, change in water table elevation and the flux of water to lakes. A water budget for the recharge area of an aquifer is a very useful means of determining ground water recharge.

The general equation of water balance in a given catchment area could be given as follows:

$$\text{Inflow} = \text{Outflow} \pm \text{Change in storage}$$

Long term change in storage can be assumed to be Zero for basins of Mojo river size. Moreover the topographic watershed is assumed to coincide with the groundwater divide. Accordingly the water balance equation can be simplified to:

Precipitation = (Evapotranspiration + Streamflow), if we replace precipitation calculated from Thiessen polygon method (968 mm) and the stream flow (237 mm), then the actual evapotranspiration is about 731 mm. The potential groundwater recharge can be estimated from stream flow by assuming 50% of the stream flow which is equivalent to 118.5 mm.

5.1.2 Biological environment

Vegetation

The present vegetation of Ethiopia is divided into twelve major vegetation types. The types and subtypes are: (1) Desert and semi-desert scrubland. (2) *Acacia-Commiphora* woodland and bushland (with the subtypes (2a) *Acacia-Commiphora* woodland and bushland proper and (2b) Acacia wooded grassland of the Rift Valley). (3) Wooded grassland of the western Gambela region. (4) *Combretum-Terminalia* woodland and wooded grassland. (5) Dry evergreen Afromontane forest and grassland complex (with the subtypes (5a) Undifferentiated Afromontane forest, (5b) Dry single-dominant Afromontane forest of the Ethiopian highlands, (5c) Transition between

Afromontane vegetation and *Acacia-Commiphora* bushland on the Eastern escarpment). (6) Moist evergreen Afromontane forest (with the subtypes (6a) Primary or mature secondary moist evergreen Afromontane forest, and (6b) Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland. (7) Transitional rain forest. (8) Ericaceous belt. (9) Afroalpine belt. (10) Riverine vegetation. (11) Fresh- water lakes, etc. (with the subtypes (11a) Fresh-water lake vegetation (open water) and (11b) Fresh water marshes and swamps, floodplains and lake shore vegetation). (12) Salt lakes, etc. (with the subtypes (12a) Salt lake vegetation (open water) and (12b) Salt pans saline brackish and intermittent wetlands and salt-lake shore vegetation (Friis, et al.,2010). Out of these vegetation types, the present study area belongs to what we call edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland within its ecosystem. As a result the majority of the species recorded from the study area are given in Table 10.

Table 10: Common plant species found around the study area

Botanical Name	**Family**
Acacia albida Del.	Fabaceae
Argemone mexicana L.	Papaveraceae
Balanites aegyptiaca Del.	Balanitaceae
Barleria quadrispina Lindau	Acanthaceae
*Dodonaea angustifolia*L.f.	Ebenaceae
Euphorbia petitiana A.Rich.	Euphorbiaceae
Heteropogon contortus Roem. & Schult.	Poaceae
Leucas martiniensis (Jacq) R. Br	Lamiaceae
Parthenium hysterophorus L.	Asteraceae
Plantago lanceolata L.	Plantaginaceae
*Rumex nervosus*Vahl	Polygonaceae
Triumfetta rhomboidea Jacq.	Tiliaceae

Figure 13: Type of vegetation in the study area

Wild life and birds

There is no reserved area for wildlife conservation; as a result only limited wild animals like hyena, monkey, warthog, rabbit and fox are abundantly existed.

The migratory birds are abundantly found around disposal sites in abattoirs areas and tannery areas.

5.2. The social Environment

5.2.1. General

According to the understanding of practitioners of social impact assessment, the operation of existing factories affect local people living in the study area in many aspects. The social impact assessment is required to investigate the impact of tanneries operation on the wealth, health and safety of the people and the surrounding environment. It is expected that the tanning industries generate demographic change e.g. size and composition of resident population as the result of influx of temporary work force (disrupts the cohesion of a small, stable community) and environmental change e.g. environmental pollution due to liquid, solid and gaseous wastes generation..

The main types of social impact that occur as a result of the tannery operation at Modjo town can be grouped into the following but not limited to four overlapping categories:

- Cultural impacts on shared customs, values, language, religious belief and other elements which make a social or ethnic group distinct;
- Lifestyle impacts on the way people behave and relate to family, friends and cohorts on a day- to-day basis;
- Community impacts on infrastructure, services and activity networks,
- Health impacts; on mental, physical and social wellbeing, although these aspects are also the subject of health impact assessment.

5.2.2. Baseline Socioeconomic Condition of the study area

The study area; Modjo town is located in the Eastern Shewa zone of Oromia region at about 70km distance from Addis Ababa along the high way running to Adama. The study area is located in Shera- Dibandiba, Tafi Abo, Kuruma Fatole Momo-Shoki Kebele and Muda Senkeli . Those kebeles were under Lume woreda administration, currently, the Kebeles are under the Modjo town administration, capital of Lume woreda. As most of the kebeles are included under Modjo town where the study area is located administratively and incorporates under its plan boundary the baseline socioeconomic condition of Modjo town is considered. Currently, Modjo has a total area of 5161.185 hectares.

Modjo town is one of the major towns of Oromia region in general and East Shewa zone in particular. The majority of the populations living in the town are engaged in trade economic activities. Plus since recently, the growing industries in Modjo town have created job opportunity to about 6017 population on contract and permanent basis.

Population

According to 2019 census by the Modjo town administration, the number of dwellers is 93,264 out of which 45,034 are male and 48,230 are females**.** ***Source: General Profile of Modjo town in 2012 E.C (2019).***

The town still has high potential to grow in terms of population size and economic development associated with the growing investment in the town and its environs.

Social services

There are 10 kindergartens, 15 primary schools, 6 secondary and preparatory school, and 5 colleges and TVETS. In the health aspect, there are 2 health centers, 1 privately owned hospital and 9 privately owned clinics. As data obtained from Modjo town Health Centre (***General Profile of Modjo town in 2012 E.C (2019).***), the top ten diseases which have been prevailing in the town are specified in table below.

Table 11: List of top ten diseases prevailed in Modjo town

S.no	List of Diseases	Cases	Percent
1	Acute upper respiratory diseases	4369	18.2
2	Acute Febrile Illness(AFI)	3957	16.5
3	Urinary Tract Infection	2949	12.3
4	Diseases of the musculoskeletal system and connective tissue	2310	9.6
5	Epidemic typhus	1819	7.6
6	Dyspepsia	1810	7.5
7	Typhoid fever	1744	7.3
8	Infectious of the skin and subcutaneous tissue	1696	7
9	Diarrhea(Non bloody)	1690	7
10	Acute bronchitis	1688	7
Total		**24032**	**100**

Source, Modjo town health center Jan. 2015 and ***General Profile of Modjo town in 2012 E.C (2019).***

As can be inferred from the above specified list of top-ten diseases, acute upper respiratory diseases is number one and this case is attributed to the offensive stench emitted from existing tannery. This case is revealed during informant interview held with health professionals working in Modjo town Health Centre.

Water supply service is one of the major factors considered in situational assessment of social services in Modjo town. As data obtained from Modjo town Administration Office, the dwellers of the town have access to safe water supply and currently there are about 12 deep wells as a source of water supply and the service coverage is 100%.

Infrastructures

Modjo has well networked road system constructed to effective utilization of natural resources for investment. There are standard asphalted roads in three directions from the center of the town heading to different regions of the country. The Addis-Adama modern express road and Dawalle-Sebeta-Railway is crossing the town. In regard to inner road network system the town has 94.5 km gravel road, 27.4 km asphalted road and 9.3 km cobblestone covered road. The specified road networks are built by public contribution, municipal budget and government budget. With regard to electric power, the town has 24 hours electric power supply from the national grid and currently there is one substation which serves for 8436 clients. The substation has 22.7 megawatt and of this 3.7 is utilized for domestic consumption of the local people where as 19 megawatt is utilized for industrial purposes. Modjo has also well organized and efficient telecom service consisting cable telephone service, mobile service and dialup and broadband internet service. All these are indicators Modjo is well furnished with facilities captivating investment to the area.

Source: General Profile of Modjo town in 2012 E.C (2019).

Investment

Investment has greater role in facilitating the overall socioeconomic development of a given country. Based on Industrial Development Policy and Strategy formulated by Ethiopian Government, Modjo town administration has been making greater effort for reduction of poverty, creating job opportunity and recorded encouraging achievement in the investment sector. There are many factors making Modjo town to be favored by investors. Favorable climatic condition, availability of infrastructures, the focal location of the town almost for all regions of the country and availability of standard hotels in the town are the chives among the varied.

Table 12: Investment in Modjo Town

Investment Sector	Number of projects	Allotted land in ha	Registered capital in Birr	Number of commenced projects	Job Opportunity		
					Total	Permanent	Contract
Industry	56	79.982	1,733,201,331	2	35	1963	1593
Urban	9	7.0835	41,165,000	3	7	6	11
Trade	13	6.771	41,170,000	3	3	9	302
Hotel	58	15.945	357,334,145	2	11	422	691
Health	3	0.998	2,994,000	1	6	3	30
Education	5	1.546	2,856,000	2	5	1	36
Realstate	1	0.0187	2,300,000	1	4	2	18
Different	36	10.609	84942500	1	7	278	437
Total	181	122.9532	2,265,962,976	8	60	2899	3118

Source: Modjo town Administration Office, Jan.2015 and ***General Profile of Modjo town in 2012 E.C (2019).***

As revealed in table 9, there are 181 investment projects registered by the investment section of the town and out of them 83 commenced tasks and a total of 6017 persons employed, (48% permanently and 52% on contract base). Data obtained from Modjo town indicates that about 76.6 ha of land made ready for investment. Thus Modjo is still waiting additional investors and welcomed enthusiastically.

Tourist Attractions

Modjo has very captivating natural tourist attractions such as Modjo river fall, cave known as *Holqaa Haileebaqatu*, by the local people and cliff which is referred as *Bowa Moshe* by the local people.

6. Impact identification and analysis

6.1. Introduction

The details about the impact of tanneries in Modjo town has been conducted through field survey, water sample collection and analysis , informant interview, and expert judgments have formed the basis to predict the impacts in particular on receiving water body i.e. Modjo river stretch along with the relevant components of the environment .

Baseline environmental conditions of the study area are described in the previous of this document. An attempt has been made to identify the impacts due to tanning industries operations on Modjo town.

Identification of the impacts which are occurring due to tanning activities is an important aspect of environmental impact studies. An attempt has been made to identify the environmental impacts due to different tanning operation involved in the study area by establishing cause effect relationship through impact identification matrix as given at Table 13. Different activities involved in operation passes of the tannery has been listed below.

6.2. Identification of Activities

Activities to be undertaken for the study area during operation phase of the tanneries:

1. Operation of Tanneries and treatment plants
2. Disposal of solid wastes and discharge of treated effluent
3. Odor emitted from tanning waste water treatment facilities and solid waste disposal sites.

6.3. The Environmental Attributes

Environmental attributes are likely to be affected due to activities involved during operation phase of the tanneries.

i. Water

- a. Quantity
- b. Quality
- c. Surface & Ground Water hydrology

ii. Land

- a. Topography
- b. Land use pattern
- c. Soil characteristics

iii. Biological Environment

- a. Flora
- b. Fauna

iv. Air Environment

iv. Socio-economic- Employment generation

v. Occupational Health & Safety

6.4. Impact Identification Matrix

Impact identification matrix has been developed by establishing cause-effect relationship between activities of tanneries and environmental attributes stated at section 6.2 & 6.3 respectively. The same has been presented at Table 13.

Table 13: Environmental impact Identification matrix

Environmental attributes	Operation of Tanneries and treatment plants	Disposal of solid wastes and discharge of treated effluent	Odor emitted from tanning waste water treatment facilities and solid waste disposal sites
Water			
Quantity	x		
Quality	x	x	x
Surface and ground water hydrology	x	x	
Air			
Air quality	x	x	x
Land			
Topography		x	
Land use pattern		x	
Soil characteristics	x	x	
Biological Environment			
Flora	x	x	x
Fauna	x	x	
Socio-economic environment			
Employment generation	x	x	
Occupational Health and Safety	x	x	x

6.5. Environmental impacts of tanneries

Environmental impacts due to operation of tanneries are identified. Impacts were evaluated using engineering judgment and comparing with best management practices. The impacts during the operation phase of tanneries are addressed below.

6.5.1. Operation Phase of Tanneries

(1). Air Environment

In tanning operation activities like liming and deliming process, there are nuisances odor generated and discharge to the treatment facilities. The treatment plant operation having different operations from screens up to biological facilities and sludge management that would create odor nuisance. Greenhouse gases such as CH_4, NOx and CO_2 are expected to be generated from the open landfill. In solid management practice, the distance of the existing municipal open landfill from the existing tannery is about 8.1 kms. In transporting the sludge as well as the solid waste, the trucks are using diesel as fuel during transportation which is seen as source of GHG emission. Inadditions, the tanneries are using boiler and generators as source steam and energy respectively that would create an air pollution environment.

(2) Noise Environment

During the tanning operation phase, the sources of noise shall be process equipment, waste treatment machinery, pumps, blowers, generator sets and vehicular movements.

(3) Water Environment

Discharge of treated effluent which many not complying with norms of discharge standards, in Modjo River will substantially affect quality of the river which is presently not in satisfactory condition. An assessment of the quality of the river sample laboratory analysis results are shown in table.

Table 14: Results of the water sample from Modjo river September 29, 2021 insitu measurement

Sample Point	Northing	Easting	Elevation	EC	TDS	pH	Temp	Remark
Modjo River Upper Catchment	$8^0$36’43’’	$39^0$06’52’’	1765	337	154	7.6	25.8	Modjo River upstream before receiving any industrial waste
Modjo River lower Catchment	$8^0$33’23’’	$39^0$05’46’’	1708	588	268	8.4	26.7	Modjo river after receiving effluent and municipal waste

Table 15: Laboratory Test result of upper and lower catchment of Modjo River

Parameters	Sampling points			WHO, standard for river water
	Upper Catchment of Modjo River	Down Catchment of Modjo River	Pollution load Increment, Percentage	
pH	7.60	8.40	9.52	6.5-8.5
COD (mg/L)	56.50	104.7	46.04	10
TSS (mg/L)	20.00	52.00	61.54	50
Total Nitrogen(mg/L)	40.00	42.00	4.76	-
TKN (mg/L)	28.00	28.00	0.00	-
Sulphide (mg/L)	0.90	1.30	30.77	-
Chloride (mg/L)	95.00	110.00	13.64	-
Chromium III(mg/L)	8.7	17.4	50.00	-
Chromium VI(mg/L)	0.01	0.01	0.00	-

The results shows that the pollutants concentration for EC, TDS,pH, COD, TSS, TN, TKN, Sulphide, Chloride and Chromium increase in the lower catchment of Modjo river as compared to upper catchment. In addition, the pollutants concentration in the river is higher than WHO standard indicating that the river is polluted. The contribution tanneries for the pollution of Modjo river can be seed particularly with the presence and increment of pollutants like sulphide and chromium which are mainly discharged from tanning industries.

Table 16: Results of the ground water sample taken from bore hole at different tanneries found in Modjo town

No	Parameters	Unit	Waste Water Sample Points			Previously Ground water Test result (Friendship Tannery bore hole)	WHO Standard
			Ground Water (CODE-6)	Ground Water (CODE-7)	Ground Water (CODE-8)		
1	Turbidity	NTU	0.23	2.13	0.511	0.722	<5
2	Odor	Non.obj.	Non.obj.	Non.obj.	Non.obj.	Non.obj.	Non.obj.
3	Taste	Non.obj.	Non.obj.	Non.obj.	Non.obj.	Non.obj.	Non.obj.
4	pH	-	7.1	7.02	7.07	6.64	6.5-8
5	Total Dissolved Solids (TDS)	mg/l	**898**	**4180**	**651**	318	**600**
6	Electric conductivity (EC)	µs/cm	1821	7770	1344	657	-
7	Total Alkalinity as $CaCO_3$	mg/l	393.2	349	361.6	52.2	-
8	Total Hardness as $CaCO_3$	mg/l	506.6	4236	522.8	192.8	-
9	Calcium Hardness as $CaCO_3$	mg/l	418.8	2858	484.4	114.2	-
10	Magnesium Hardness as $CaCO_3$	mg/l	87.8	1378	38.4	78.6	-
11	Ammonia as N	mg/l	0.30	**4.60**	0.39	0.04	1.5
12	Nitrite as N	mg/l	0.06	0.016	0.009	0.003	1
13	Nitrate as N	mg/l	2.40	8.2	1.8	0.6	11
14	Sulfate as SO_4	mg/l	80	**460**	43	8	250
15	Phosphate as PO_4	mg/l	0.52	0.43	0.35	0.81	-
16	Fluoride as F	mg/l	1.0	1.14	1.5	1.1	1.5
17	Total iron as Fe	mg/l	0.05	0.13	ND	0.01	0.3
19	Manganese as Mn	mg/l	0.063	0.224	0.07	0.022	0.1
29	Silica as SiO_2	mg/l	65	58	67.5	54	-
20	Chloride as Cl	mg/l	**299**	**612.75**	240.75	2.5	250
21	Bicarbonate alkalinity as HCO_3	mg/l	393.2	349	363.6	52.2	-
22	Carbonate alkalinity as $CaCO_3$	mg/l	Nil	Nil	Nil	Nil	-
23	Hydroxide alkalinity as $CaCO_3$	mg/l	Nil	Nil	Nil	Nil	-

ND-Not detected

The result from the ground water sample analysis for sample Code 6 and Code 8 indicate that the quality of the water is in compliance with most of the parameter of WHO standard. The value of TDS exceed the WHO standard, this may due to the geology of the area. In general the quality of the ground water of the thee area satisfy drinkable water quality.

(4) Land Environment

Hazardous solid wastes, chemical sludge produced during the wastewater treatment is disposed in open landfill designed which have high impact on the soil and water.

Currently, the open landfill is closed due to public complain for more than one year , while in the month of September , 2021, the local solid waste collectors agreed with the farmers to dispose the solid waste pilled at the tanneries premises. The disposal agents charged the factory, about 1600 birr per truck (including loading, hauling and disposal) .Accordingly, about 300 trucks of solid wastes of different types were disposed until the permit was interrupted due to public complaints of nuisance odor. The figure blow shows, the open landfill of Modjo town for both municipal and industrial waste during the audit.

During the impact assessment period, the town administration planned in 2013 E.C (2019/2020) to collect about 56,100 m3 of solid wastes but it has collected 44,239 m3 (~80). The plan was to recycle 6380 m3 of wastes while, the execution was above the plan, 9958 m3(~156%). There were four micro enterprises having a total 11 person involved in solid waste collection at the town and benefited from selling of recyclable wastes like plastics with 3 birr/kg.

The consultant had collected soil samples from different areas of the open land fill and downstream of Modjo river side to assess the level of impact by the tanning industries operation. The soil samples were analyzed by third party laboratory and the results are compared with WHO standards.

Table 17. Results of soil samples analysis from open landfill and downstream Modjo river side

S.N	Parameters	Open landfill	Modjo river side	WHO Standard	Remark
1	pH	8.20	8.90		
2	Electrical Conductivity, EC (mS/cm)	10.61	1.21		
3	Organic Matter, OM (%)	6.74	1.48		

4	Total Nitrogen, TN (%)	0.74	0.16		
5	Moisture (%)	5.66	6.78		
6	Copper, Cu (mg/Kg)	443.08	157.69	36	Exceed the standard
7	Zinc, Zn (mg/Kg)	166.42	157.69	50	Exceed the standard
8	Chromium, Cr (mg/Kg)	7995.55	355.07	100	Exceed the standard
9	Cadmium, Cd (mg/Kg)	3.18	4.29	0.8	Exceed the standard
10	Lead, Pb (mg/Kg)	51.94	53.64	85	Exceed the standard
11	Total Phosphorus, TP (mg/Kg)	206.43	168.15		
12	Potassium, K (mg/Kg)	3126.99	4451.83		

The results showed that the soil samples taken from the open landfill and Modjo river side exceed the permissible standard by WHO. This indicates that the soil is contaminated and not suitable for agricultural activities.

Figure 14: Open landfill for tanneries solid wastes and municipal wastes.

(5) Ecological Environment or Biological Environment

The biosystem of the river is highly affected due discharge of wastes from the tanneries. As the Modjo town and its surrounding areas had terminated irrigation activities due to the impact of pollution on Modjo river resulting in very low productivity of the river irrigation. Therefore, the consultant had taken a sample from open market of Modjo town, irrigated at Koka areas, which is found downstream side of Modjo River. The table below shows the result of laboratory analysis for

heavy metals found in vegetable samples compared with the WHO permissible limit.

Table 18. Result of vegetable samples analysis and comparison against WHO permissible standard.

S.N	Parameters	Vegetable	WHO Permissible limit	Remark
1	Chromium, Cr (mg/Kg)	22.17	1.3	Exceed the standard
2	Copper, Cu(mg/Kg)	2.50	10	Meet the standard
3	Zinc, Zn (mg/Kg)	12.17	0.6	Exceed the standard
4	Nickel, Ni (mg/Kg)	1.50	10	Meet the standard
5	Cadmium, Cd (mg/Kg)	ND	0.02	Meet the standard
6	Lead, Pb (mg/Kg)	5.50	2	Exceed the standard

*ND-Not detected

The results showed that the vegetables samples are contaminated with heavy metals like Cr, Zi, and Pb which can creat potential health risks to consumers. The tanning industries utilize different input raw materials that contain heavy metals, so probably the heavy metal contamination can be due to the discharge of wastewater from the tanning industries.

6.6. Social impacts

Community participation is the most favored approach for effectiveness and sustainability of development activities. With this understanding key informant interviews, focus group discussions and meeting with different stakeholders like local government officials were held in study area. Key informant interviews and focus group discussion was carried out with the objective of identifying the potential social impacts (positive and negative) and on the implementation of the proposed mitigation measures for the negative impacts. It also gives opportunity for the affected people to influence the tanning industries to reduce adverse impacts and maximize additional benefits. The different groups of associations, public and private organizations, community groups and individuals who participated in the key informant interview and stakeholders consultations include;

- Modjo town administration, Modjo town land management office to discuss about the kebeles under town administration with Mr. Kebede Abera,
- Modjo town Environment, Forest and Climate change Authority office Mrs.Senait Megersa and Ms. Jiratu Daba,
- Different workers at Modjo town Finance and Economy office to address Modjo town profile,
- Modjo town Health office Mr. Tulu Bedada ,Medical Director to discuss about health impact ,
- Town residents, Farmers and animal herders etc.(about the impact of solid waste disposal and Modjo river)
- Solid waste collectors, and glue manufactures were interviewed about all the social issues related to the tanning activates impact on the society.

The output of the informant interview and focus group discussion

On the basis the focus group discussion with Modjo town land administration team chaired by the team Leader (Mr. Kebede Abera), the study teams were informed that the former kebeles under Lume woreda administration were included under Modjo town administration. Those kebeles which are include in Modjo town administration (Muda Sekele, Shera debandeba,kurma fetale, Tafi Abo and Momoshoke) are parts of the study area. On the other hand, a discussion was made with Modjo town Environment, Forest and Climate change Authority about the impact of tanning activities on Modjo river, solid waste disposal practices and complaints from the society. According to the

discussion the authority inspects the tanneries on monthly and provide feedbacks to improve their environmental management performance. Besides, the regional EFCCA along with the town EFCCA monitor the quality treated waste water compliance against the national standard on biannually basis. However, the authority did not well documented study about the impact of tanning industries on Modjo river in particular the town in general. During different times, there were scholars conducted a research in support of the authority, but the results of the studies were not shared to be used as a baseline information.

Based on the discussion with Modjo town health center team chaired by Mr. Tulu Bedada, Medical Director of the center, it was understood that the health impact related to tanning activities in the town (upper respiratory tract disease) is one of the top disease prevailed in Modjo town. But, nowadays there is improvements in the number cases related to tanning industry activities.

Interview with Farmers and animal herders about the impact of solid waste disposal and Modjo river issues, the farmers were affected by the floc birds disposing solid wastes trashes on their farmlands that would affect their productivity. Besides, the herders complain that their animals could not get drink Modjo river as it has bad smell for animals. However, the open disposal site has been closed for more than one year which reduces the number flock birds coming to the disposal site.

The study team has also discussed with solid waste collector, plastic recyclers and glue manufactures. According to the discussion, the solid waste collectors were recycling plastic materials unsegregated wastes disposed on open land fill. Inaddition, glue manufacturing association accommodates about 30 people are using the solid waste (pelt trimmings and lime splits) from different tanneries to produce glue that utilize solid waste which could contribute to bad odors and greenhouse gases emission.

The picture taken during the audit time is shown below.

Figure 15: Pictures of glue production, solid waste disposal open landfill and bird flocks

The potential positive and negative social impacts created by the tanning industries were identified through field observation, meetings and discussions held with tanneries beneficiaries, town administrators and experts.

In general, the major points recounted during the key informant interview and government workers discussion, the impacts are listed down categorized as positive and negative.

Positive impacts

Employment opportunities for local communities

- The tanning industries create employment opportunities for the local communities. The youth and women residing benefit from the employment opportunities created due operation of the tanning industries. It can be assumed that this will have a significant contribution to the reduction of poverty at the household level.
- It creates good opportunity for the livelihood transformation of the local people from subsistence agriculture to industry based livelihood economic system
- In general, the tanneries contribute to the creation of jobs and income, and improvement of the local economy; increase the revenue capacity of the area, and will also bring development in skills and knowledge to the locality. In the process of employment, the tanneries is expected to abide with the labor code of the country.

Creation of income generating activities

Creation of income generating activities is one of the positive impacts of the project to the local community. There is also income opportunities that is created to residents in the study area during tanning operations. Businesses such as, catering services (small bars and restaurants) located in Modjo town could earn additional income due to the presence of large numbers of workers at the tanneries.

Besides this, solid waste collection recycling and disposal has created job opportunities for about 40 people in plastic recycling, disposal, and glue production. It increases the income through plastic waste recycling and glue manufacturing at company and individual levels.

Negative impact

- Failure of the tanners engaged to keep the promise they pledged to the community and local administration in regard to maintaining the environment from pollution urged the local people to lose trust on the operation of the tannery. Thus, most informants have expressed their suspicious in consistent effort and monitoring to make the tanneries are environment friendly and socially acceptable.
- Participant from Modjo town health office indicated that; upper respiratory diseases are among the top-ten diseases prevailing consistently in Modjo town and its environs. These diseases are closely linked with offensive smell emitted from existing tanneries and pollutant substances discharged from existing factories and draining to Modjo River.
- The tanners entail the influx of several people to Modjo town which creates pressure on the existing social services like housing units, education institutions, health services and water supply services.
- The tanneries found in Modjo would have community health cost, loss of productivity of farmers, and animal health cost impact.
- The introduction of new and alien cultures and behaviors may contribute to the spread of communicable diseases such as sexual transmitted disease like HIV/AIDS. Similarly, other unwanted experiences such as, the coming of sex workers to the town from major towns and cities will contribute to the increase in the number of sex workers, alcoholism and crime.

6.7. Economic Impacts

Employment generation

The tanneries found in Modjo creates about 3500 direct employment opportunities for the local communities which include both skilled workers and unskilled workers About 55% of the total employees are female and 45 % are male. But, indirectly, it creates for about 15,000 people.

The employment potentiality of the tanneries ameliorate the economic condition of the families of those persons who are employed in the tanneries. In addition, it creates indirect employment for a number of people who will be involved in the business and service oriented industries.

Export Earning

The tanneries found in Modjo generate about 70% of the total export earnings from all tanning industries in Ethiopia which is source of hard currency for the country. According to the year 2020/21, the tanneries have generated a total export earnings of 18 million USD (out of 26 million USD exported from this sector) from export of pickle/wet blue, crust and finished leather.

Technology transfer

It creates a modalities of technology transfer through tanneries and establishment of the research center in the Modjo town (Leather Development Institute has established branch offices in Modjo town and TVET related to leather sector) are special benefit to the region in particular and the country at large.

Consumption Pattern

Increased household income has enhance the consumption pattern of few selected households who would be benefitted by getting employed in the tanneries directly or indirectly.

Impact on utilities

Utilities including supply of water, electricity, gas and sewage facilities. The residents in the neighborhood are getting and accessing utility services such as water supply, electricity, gas and sewage facilities due to the existence of such cluster of tanneries.

Infrastructural Development

The increasing infrastructural activity will boost the commercial and economic status of the locality that will be helpful to further boost the industrial development especially small scale industries so that large number of local people will be benefitted.

The negative economic impact of the tanneries found in Modjo would have community health cost, loss of productivity of farmers, and animal health cost that would affect the whole economy.

7. Mitigation measures of the anticipated Environmental Impacts

7.1. Tannery Operation Mitigation Measure

(1) Air Environment

- G o o d housekeeping is required to reduce air emissions and bad odor from tannery premise
- The vehicles have to be maintained in good running condition by regular servicing.
- Roads in industrial should be maintained in good condition and tarred so that dust emission will be minimum.
- The boilers and generators shall be provided with a stack of proper height for the proper dispersal of pollutants emitted from the stack.
- The sludge discharged from primary and secondary clarifier has to be dewater properly and disposed to the disposal areas immediately so the major cause of foul smell can be eliminated.
- The tanneries shall develop adequate peripheral green belt, the odor nuisance will remain minimal.
- The governments shall construct secure landfill that can accommodate both hazardous and nonhazardous wastes having leachate recovery &treatment as well as gas control.

(2) Noise Environment

- The generator sets should be provided with integral acoustic enclosure at the manufacturing stage itself" Accordingly, "Generator sets with integral acoustic enclosure will be purchased and will be installed in acoustic rooms.
- The noise producing machinery should be changed with new machineries having low noise level and also i n place them in a separate room having closure t o reduce the noise levels.
- Workers working near noisy area shall be provided with personal protective equipment's like ear plugs and muffs.
- Roads shall be maintained in good condition to reduce the noise due to traffic.
- Peripheral green belt has to be properly developed to absorb the noise.

(3) Water Environment

- Discharge of excess treated effluent shall comply with norms so that it will substantially improve the present quality of the river which is presently not in satisfactory condition.
- The treated effluent from ETP shall be recycled and reused to the maximum extent.
- Domestic wastewater from industrial areas and from office / canteen will be treated along with industrial effluent stream.
- The environment protection shall monitor the tanneries treatment facilities and quality treated waste discharge to the river with unbiased and professional ethics.
- The Leachate generated from the open landfill cell(s) shall be temporarily stored treated so that the impact on the river would be minimized.
- The governments shall construct secure landfill that can accommodate both hazardous and nonhazardous wastes having leachate recovery &treatment as well as gas control in which the current scenario is sustainably improved.

(4) Land Environment

- Hazardous chemical sludge has to be sent by authorize disposal agents to secure land fill designed for this purpose.
- The Primary sludge containing some toxic elements such as chromium, cadmium, nickel etc. from the process inputs shall be properly disposed with the proposed secure landfill for hazardous wastes so that the land and soil shall not be affected.
- The trimmings and fleshings shall be used as manure after preparing compost which be used as conditioning for peripheral green development that will keep the land environment attractive.
- Record of sludge disposal shall be kept as per hazardous waste (management, handling and transboundary) rules of Ethiopia

(5) Ecological Environment

- Tanneries in general shall be properly operate their facilities to induce beneficial effect on the environment by reducing pollution
- The proper operation and monitoring of ETP will reduce in the discharge pollution load

of industrial effluents in the adjoining Modjo River and this will be helpful in restoring the quality of the river.

- Monitoring and compliance discharge standard will eliminate such unwanted eutrophication boosting up the aquatic life with high DO content with necessary nutrients.
- The effluent discharge shall comply with the norms aimed at and to the stipulated norms of environmental authority will not be harmful to the ecology of the receiving river.
- Green belt/ plantation shall be developed around the tanner ETPs and buffer zones.

(6) Socio –economic environment

- The tanners shall ensure women's employment and improve their employment opportunities and working conditions. Develop guidelines and regulations to ensure that women receive equal employment opportunities.
- The tanners needs to observe the labor code of the country for employment, minimum wage, work safety regulations, and related issues.
- The government shall make available micro credit services for small entrepreneurs working in partner with the tanner in providing raw hide and skins and manufacturing articles, solid waste disposal agents and glue manufactures.
- Building of housing units for the factory workers or formulating mechanism and implementing making the dwellers of the town to be owner of housings.
- Building additional number of schools in different levels for determining principal balance between all school age population living in the town and schools.
- Building additional number of health services to create access to all dwellers of the town as per the policy framework.
- Conduct education and awareness creation campaigns on the spread and transmission of sexual transmitted diseases like HIV/AIDS for factory workers and local communities living close to the factories.
- Monitor the above mitigation measures through proper monitoring indicators.

8. Environmental Management Plan

8.1. Introduction

An Environmental Management Plan (EMP) is site specific plan developed to ensure that the tanning industries are operated in an environmentally sustainable manner in Modjo town. The plan helps all stakeholders including the tanners, regulatory bodies, researchers and consultants understand the potential environmental risks arising from the tanning industries operation in Modjo town and lay out appropriate actions to be taken to properly manage that risk. The EMP ensures that adequate environmental management measures are incorporated during the operation of phase of the tanneries to minimize any adverse impact and to realize sustainable development of the area. The EMP is required to ensure sustainable development in study area of the tanning sites. Hence, the EMP needs to be an all-encompassing plan for which the government regulating agencies working in the region and more importantly the potentially impacted population of the study area need to extend their cooperation and contribution. Thus, EMP has been formulated for mitigation of the adverse impacts and is based on the present environmental conditions. This plan helps in formulation, implementation and monitoring of environmental parameters during the operation of the tanning industries.

8.1.1. Objectives of Environmental Management Plan

The main objectives in formulating the environment management plan are:

- To properly treat the effluent generated by the tanners so that the effluent can be recycled & reused in the industrial units or safely discharged in the Modjo river.
- To generate a research document on the impact of tanning industries on Modjo town
- To minimize the air emission, noise and hazardous waste with appropriate technology.
- To comply with all the regulations stipulated by the respective environmental protection authorities to liquid effluents discharge and air emission as per air & water pollution control laws.
- To encourage the member industries to carry out minimum up to secondary level (biological) to comply norms and standards.

- To handle hazardous waste as per hazardous waste (management, handling and transboundary movement) amendment rules of Ethiopia.
- To improve the overall environmental status and methods of environment management.
- To establish green belt/plantation/garden/lawn around the study area to improve the aesthetics of the area.
- To create good occupational environment for the benefit of the employees to improve their work efficiency.
- To take effective measures to curb the fire and accidental hazards on the tannery site.
- To arrange regular medical health check-up of the employees and to provide the medical aid to them.
- To conduct the skill up-gradation training programs for the employees and training on preventive measures and conduct during on-site and off-site emergency conditions.
- To allocate the required funds for the effective environmental management.
- To dissemination of technological solutions on commercial basis to interested parties.
- To continuously develop and search for innovative technologies for better environment.
- To adopt cleaner technology.

8.2. EMP during tannery Operation

The tanning industries shall follow best available technologies and cleaner production approaches to reduce the impact on the workers and surrounding environment. The wastes discharged from the process operations like liquid, solid and gaseous wastes should be controlled, treated properly to fulfill the emissions standards.

8.2.1. Water Environment

- The tanners shall monitor the water to be used for the process as well as discharge to water body
- The treatment facilities should worked with the appropriate operational procedure and manual.
- The tanner ETP shall be strictly monitored with appropriate sampling and analysis against the norms and standard.
- In case of failure to satisfy the inlet norms by tannery, appropriate punitive action will be taken.
- The performance of ETP shall be continuously monitored for the effluent quality parameters and any deviation in performance will be subjected to corrective measures through root-cause analysis.
- Preventive maintenance schedule for ETP machineries shall be prepared and strictly implemented to ensure the effective and efficient operation of ETP units.
- Enough care should be taken to prevent any leakages / accidental spillages from ETP treatment units.
- Reputed institution (third parties) shall be requested to conduct periodic sampling and analysis at inlet, outlet, and intermediate stages and within the aeration tank to determine plant performance.

8.2.2 Biological Environment

Tree plantation is one of the effective remedial measures to control the air and noise pollution. It also causes aesthetics and climatologically improvement of area as well as sustains and supports the biosphere. It is an established fact that trees and vegetation acts as a vast natural sink for the gaseous as well as particulate air pollutants due to enormous surface area of leaves. It also helps to attenuate the ambient noise level. Plantation around the pollution sources control the air pollution by filtering the air particulate and interacting with gaseous pollutant before it reaches to the ground. Tree plantation also acts as buffer and absorber against accidental release of pollutants. The selection of tree species suitable for plantation at the tanneries buffer areas and ETP shall be governed by guiding factors as stated below:

- The trees should be tolerant to air pollutants present in the area
- The trees should be able to grow and thrive on soil of the area, be evergreen, inhabitant, having minimum of leaf fall. Local species will be preferred.
- The trees should be tall in peripheral curtain plantation and with large and spreading canopy in primary and secondary attenuation zone.
- The trees should possess extensive foliar area to provide maximum impinging surface for continued efficient adsorption and absorption of pollutants.
- The trees should be fast growing and indigenous and should maintain ecological, land and hydrological balance of the region.
- It is also recommended to plant few trees, which are sensitive to air pollution, as air pollution indicator.
- It is also recommended to carry out extensive plantation within premises.

8.2.3. Odor Management Plan

In order reduce odor nuisance with the tannery premises and its surroundings the following control measure shall be implemented:

- Essential aspects of odor control equipment's shall be adopted.
- In the management of raw materials and during the treatment process, aerobic condition will be maintained.
- The odorous compounds like sulphide liquors shall be oxidized by using oxidizing agent as per

requirement.

- During operations of , necessary precaution shall be made to avoid overloading different process units.
- During operation of ETP, turbulence in effluent flow shall be minimized.
- Avoiding the solids inventory and sludge backlog.
- Necessary measures shall be taken to control the release of aerosols.
- The sludge generated by the treatment plant shall be continuously and safely disposal.
- ETP shall maintain Proper operating condition.
- The tanneries shall have proper housekeeping.
- The Green belt shall be developed in a way its shield air or odor toward the Mojdo town and by using plants that release pleasant fragrance.

8.2.4. Occupational Health and Safety

- Face shields, goggles and safety glasses, gloves, rubber / Gum boots, Protective clothing / apron, respirators, dust masks, helmets, work clothes, nose mask, shoes and working manuals shall be provided for workers.
- Recruit safety office and nurse for welfare of the workers.
- Different light lifting machines for work simplicity,
- Workers training on how to use safety materials and keep safe working place and use of safety instructions in the production process,
- Accidents control, investigations, analysis and reporting in the company processing activities.
- Post, mark and label safety signs at appropriate places.
- Regular workers health check-up or examination in every year especially for workers exposed to chemical and emissions.
- Providing information, instruction and training enabling employees to work without hazards;
- Control workers to properly use its personal protective clothing and equipment in a regular basis.

- Ensuring all work procedures are undertaken without exposing workers to hazards.
- Practice mock emergency drilling at different times.
- Provision of adequate welfare and sanitation facilities as well as first-aid measures considering the heavy contamination.
- Provision of separate eating facilities to avoid food poisoning.
- Effective arrangement for monitoring health of staff.
- Emergency showers and eye-baths shall be situated close to the site of any potentially hazardous work processes.
- First-aid boxes shall be provided in all work areas and workers trained in emergency first- aid procedures for any accident or chemical exposure.
- Telephone number in case for medical assistance and ambulances shall be prominently displayed in the work place and a telephone must be available for use in case of emergency.
- There shall be an Emergency Response Plan (ERP) in which individuals are assigned to perform certain tasks.

8.2.5. Solid waste management plan

One of the major challenge currently facing the tanning industries is lack of proper disposal site for high amount of solid generation from the production process. As due attention is require for solid waste management, a solid waste management strategy is proposed by the consultant which is dealt in detail in the next chapter.

9. Solid waste management strategies

9.1. Introduction

With the twenty first century, great changes and developments are taking place in our world affecting our life. The fact that the shortage in inclination of natural products with the increase of industrial production causes to related environmental problems and turns our existence to technological life is a serious and up-to-date problem. Depending on these developments, production of regenerated products and reuse of wastes, which are environmental friendly and recyclable, has come to the forefront in all sectoral areas for the elimination of environmental pollution. For these reasons, the development of new production models and product forms with new and environmental friendly technologies from by-products and wastes has become extremely important for the leather industry.

The industrial tanning of leather produces considerable amounts of solid wastes and liquid effluents and raises many concerns regarding the environmental effects and escalating landfill costs. According to the input/output balance of the leather processing; 1 ton raw hide might be converted only 200-250 kg of finished leather, that 50-75% of the grand total are the wastes composed of fleshings, splittings, shavings, trimmings and buffings. Because of the composition and properties of those wastes, there is a growing interest in collagenous and fatty ingredients and fibrous wastes as well.

The management of solid wastes and by-products is vital to ensure economic and environmental sustainability to a tannery sector. The identified long term strategy is aimed at reducing the production of solid wastes through recovery of materials and transforming into valuable products. This approach will ensure minimization of carbon footprint for the overall industrial processes through the recovery of organic compounds and nutrients (mainly nitrogen) and, at the same time, through implementation of state-of-the-art waste transformation technologies that will convert potential waste management costs into marketable products. About 60% of the total solid waste production can be recovered and transformed. However, the implementation of the wastes transformation facilities will require time. As a consequence, the solid waste management and the landfill consideration during the operation will have to be able to receive and treat both the sludge produced by the tanning industries and the solid wastes (byproducts) of the tanning processes.

The wide range applications of leather industry by-products and wastes in the food, pharmaceutical, cosmetic, photographic industries and composite material production industry would cover the

potential consumption of collagenic by-products and fibrous solid wastes of processing, thereby; complying with the environmental concerns. Because the potential environmental impacts of tanning industry effect all activities, the waste management and recovery becomes a current interest in the industry. Therefore; while the adaptation of cleaner processing technologies to the industry, the safe recovery of the wastes is to be investigated to convert co-products for value addition.

Tanning process by-products (wastes) can be summarized as follow:

- Fleshing (green or after liming)
- Chrome shavings
- Trimmings (green and tanned)
- Buffing dust
- Rejected materials (finished or at different processing steps)
- Miscellaneous residues from the factories, offices and other activities (papers, plastics, woods, packing materials, garden residues, etc.)
- Residual sludge from effluent treatment

When considering the actual daily processed weight of raw material and the relative waste production of each tanning unit process, the assumptions in the following table can be made:

Table 19:Summarized specific production of solid wastes from tanning processes as percentage of raw material - Residues from individual screens at the tanneries and other solid wastes

Waste type	Value (%)
Salt (mechanical desalting of raw stock)	2
Fleshing	18.9
Splits and trimmings	21.7
Shavings	11.9
Buffing dust	0.9
Miscellaneous	10
Total	**65.4**

Since the daily weight of raw material processed is 330 tons in Ethiopia, while tanneries found in Modjo town processes about 210 tons (about 64% of the country capacity), the expected production of solid waste is summarized in the following table.

Table 20: Estimated solid waste production from each

Unit Process	tons/day
Salt (desalting of raw stock)	4.20
Fleshing	39.69
Splits and trimmings	45.57
Shavings	24.99
Buffing dust	1.89
Miscellaneous	21.00
Total	137.34

Moreover, solid wastes are generated at the ETP in the form of sludge (dry concentration of sludge from filter presses = 35%), usually about 0.1 to 0.12 kg of dry matter (DM) per 1 kg of processed raw. Thus, expected solid wastes from tanneries and generated at the ETP are about 156 tons per day.

Table 21: Estimated total solid waste production

Solid Waste Generation	ton/day
Solid wastes generated at ETP	16
Solid wastes from tanneries	140
Expected total solid wastes	**156**

The possibility of recovering tanning by-products depends on the characteristics of each material and on the marketability of each product. The most important characteristics for by-products composed of organic compounds (the largest part of tannery solid waste) are:

- **The concentration of nutrients:** several by-products contain significant fraction of proteins and have high concentration of nutrients that can be reused as fertilizer or animal food;
- **Collagen concentration:** when residuals that contain proteins, also have a relevant fraction of collagen, glue and gelatin can be produced. Their use will depend on the contamination with reagents (such as chrome), that is, it will be different for tanned and untanned by-products;
- **The concentration of lipids:** fleshings contain both proteins and lipids that can be separated through physico-chemical processes and valuable fat can be produced.

From the total solid wastes generated there are different by products produced which are listed below having production descriptions and possible market values in near future.

9.2. Recovery of grease and proteins from limed fleshings

It is possible to recover of grease and proteins from limed fleshings. The process basically includes the following:

- Milling of the limed fleshings
- Alkaline hydrolysis (60°C)
- Separation phases: floating phase (greases and soaps) and water phase (proteins, dissolved salts and settleable materials).

Floating (grease) phase:

- sulfuric acid (pH 1) and new separation of the water phase
- neutralization and washing with water

A mixture of grease/oil (tallow) is obtained with a melting point of 30°C and maximum 30% free acids. This product may be of use for soap or animal food industries.

Water (protein) phase:

The protein solution is treated for 20 minutes at a temperature > 133°C and a pressure of 3 bar before being further processed.

- Dosage of ammonium bicarbonate and precipitation of the calcium salts as $CaCO_3$ (for avoiding $CaSO_4$ precipitation during the successive process of concentration of the protein solution);
- Sedimentation;
- Filtration of the settled sludges by filter-press (the clear filtrate is mixed with the supernatant of the sedimentation tank);
- Under vacuum concentration of the liquid phase for obtaining a final liquor with a protein content of 55-60% (concentrations below 50% are not stable).

The process also needs a final drying unit (3 steps flash-drying-tower) for the production of powdered proteins in sacks. The process gives approximately the same production in grease and proteins: 10-15% of the weight of the processed fleshings. The proteins are sold as fertilizer in agriculture in liquid or solid form. The products may be used also as integrator of the animal food. The process generates sludge with 60% water and this residue is disposed of in the landfill or given to farmers as fertilizer. The sludge produced is about 25% of the weight of the processed fleshings.

9.3. Gelatine Production

Gelatin has been produced since old ages and has an increasing use in different fields. In many countries it is considered as a natural nutrient and its consumption is increasing along with the technological developments. It has been reported that in recent years World Gelatin Production has reached up to 400 thousand tons where 65% has been produced in European countries. The recent predictions indicate that the size of the world market will increase to 652 thousand tons and the market volume up to 4.1 billion dollars.

Gelatin is a soluble polypeptide extracted from collagen. It is produced through the breakdown of the cross-linkages between polypeptide chains of the collagen along with some amount of breakage of polypeptide chain bonds. When collagen is treated with alkali or acid and followed by or accompanied with heat, the fibrous structure of collagen is broken down irreversibly yielding the product gelatin.

Gelatin is a translucent, colorless and tasteless refined protein produced by decomposition of collagen naturally occurred in skins and hides; particularly pig skins, hides, fish skins and connective tissues, that the process is a partially hydrolyzation of collagen into the smaller molecular units. It consists of 84-92 % protein, 10-12 % water and 2-3 % mineral matters.

The quality of gelatin produced in Type A and Type B having differences is dependent on the process outline and recipes and also raw material quality. Acidic pretreatment is mostly practiced in gelatin extraction from bones; namely Type A Gelatin. Alkali pretreatment yields in Type B Gelatin which is the technical way for production to a large extent in the World.

Although the gelatin source is mainly skins and hides from pigs, caw, chicken, fishes, bones and cartilages as well might possibly be used in the process. The splits obtained from hides are of the most importance for the production. The gelatin quality is described to be gelling capacity which is called bloom strength.

In the Gelatine manufacturing; the treatment of animal raw materials with diluted acid or alkali results in partial cleavage of molecular cross-links, the structure is broken down to such an extent of lower than the solubility limits, thereby; yielding “warm water-soluble collagen”; namely Gelatin. This chemical hydrolysis can be supplemented or even replaced by the use of enzymes. Special enzymes known as collagenases are required for such a process as most of the protein-cleaving enzymes do not attack the water-insoluble collagen of skin and bone. Only highly specific protein-cleaving collagenases are capable of breakdown the native collagen structure.

In the subsequent extraction step, i.e. the melting out of gelatine from raw material, an additional thermal hydrolysis step takes place. This reduces the molecular weight still further.

The amino acid composition and properties differ according to the method and the type of gelatin (Type A and Type B). This explain the different iso-electrical points between Type A and Type B. For gelatin of Type A, this corresponds to collagen at about pH 8-9 and for Type B at pH 4.8-5.5.

The production of process gelatin is as follows:

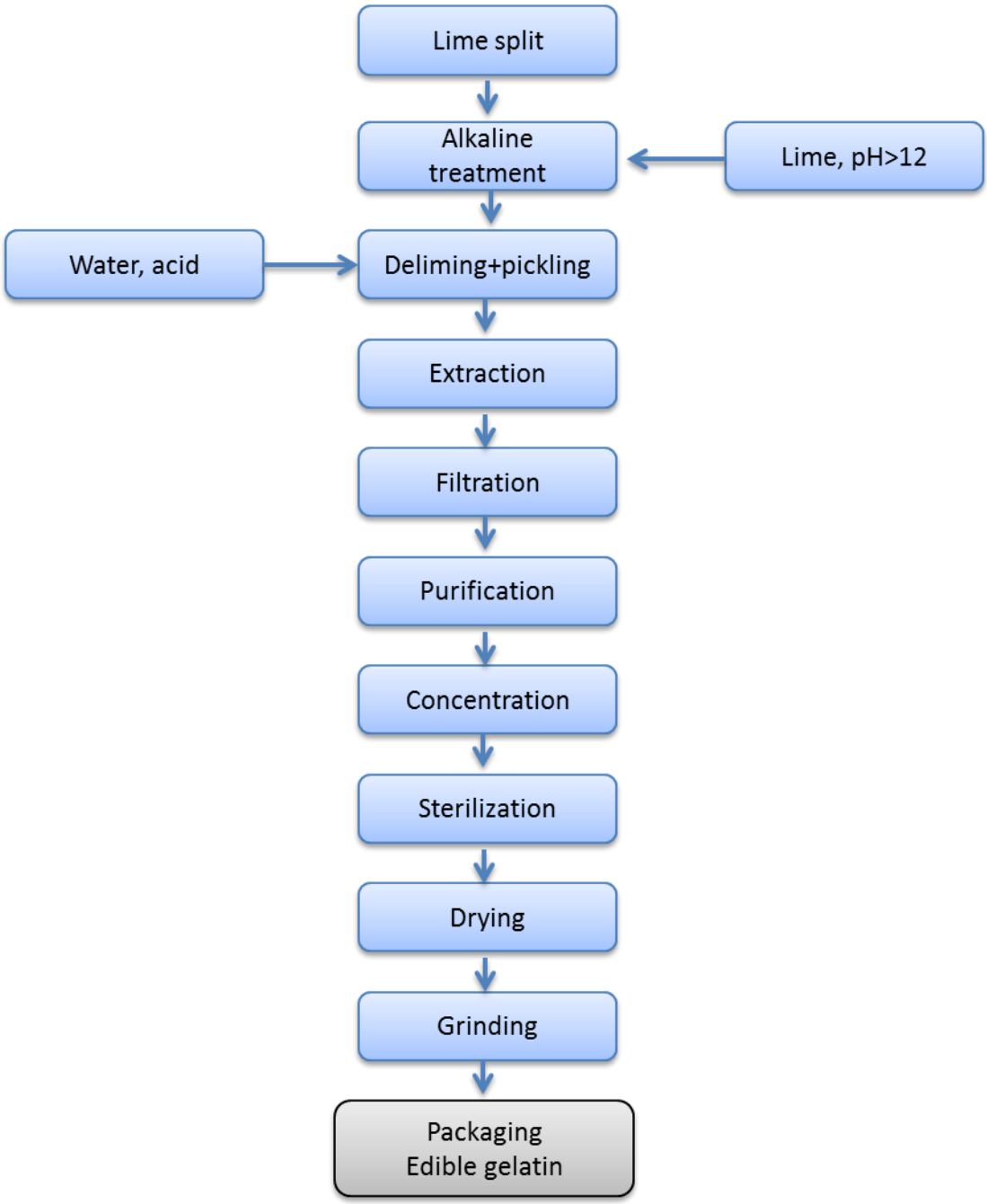

Figure 16.Stages of edible gelatin production

9.4. High grade gelatin and protein hydrolysate from trimmings

CSIR-CLRI had developed the technology for the manufacture of high grade gelatin and protein hydrolysates from raw hide/skin trimmings. In leather manufacturing process, hides and skins are trimmed and transformed into amenable products by subjecting them to chemical and mechanical processes to obtain products for meeting various needs. This operation generates huge amount of raw trimming wastes, which is account for about 7.5% of the total quantity of raw material processed in the leather industries. The predominant constituent of theses trimmings are collagen, a structural protein present in the extracellular matrix . Collagen is found in the tendons, skin, bone, connective tissue of mammalian, avian and fish species. The destruction or partially hydrolysis of cross linkages between three polypeptides chains of collagen is transformed to gelatin through extraction. Gelatin is a highly water soluble protein substance obtained from partial hydrolysis of collagen derived from the natural source of skin, bone and connective tissue of mammals. It is a translucent brittle solid substance, colourless or slightly yellow, nearly tasteless and odourless. Partial hydrolysis of collagen will result in different molecular weight of gelatin ranging from ~15kDa to 220kDa. The quality of the gelatin is determined by molecular weight distribution as well as various parameters such as bloom strength, clarity and organic content. Based on the quality, gelatin is widely used in the pharmaceutical industry to make capsules for drugs as well as in the food industry to make jelly candies, ice cream, and as thickening agent in cakes and soups. It is also used in the cosmetic, photographic, metal refining, paper industries. The gelatin industry, by investing heavily in technology, plant and equipment, has been able to continuously develop its products and open it up to new application areas. The manufacturing process selected depends on the one hand of raw material but also on the envisaged application of the gelatin produced. The raw trimmings apart from collagen also contain keratin as one of the major constituents. The technology developed by CSIR-CLRI is towards effective utilization of trimmings. For every KG (@ 30% moisture & 35% salt) of trimming waste about 160-180 grams of high grade gelatin, 70 – 80 grams of protein hydrolysate (majorly contains collagen hydrolysate and fat is a minor constituent), 30 – 40 grams of keratin hydrolysate are generated from this technology. Cost benefit of this technology is presented here under.

A. **Capital Cost –** Gelatin (for 4 tons of raw bovine trimmings/day):

- Total fixed cost for the production of gelatin = US $1.25million
- Technology Licensing fee = US$ 0.2 million

B. Operational Cost

Table 22: Costs Per Month

Items	Amount (US$ in thousands)per month	Amount (US$ in thousands)per annum
Cost of trimmings	1,500	18,000
Chemicals/Consumable	12,500	15,0000
Manpower Costs	3,000	36,000
Energy costs	12,500	150,000
Miscellaneous	1,500	1500
Interest on investment (1% Per Month)	10000.00	120,000.00
Total	**410,00.00**	**492,000.00**

Total variable cost per annum = 0.5million US$

C. Profitability

Volume of gelatin (per month @ 24 days): 16800 kgs (700 Kgs per day)

Volume of protein hydrolysates (per month @ 24 days): 9600 kgs (400 kgs per day)

Revenue generation per month from gelatin: US$ 84,000 (@US$5 per kg)

Revenue generation per month from protein (collagen and keratin) hydrolysates: US$ 9600 (@US$0.75per kg)

Total sales per annum = US$ 1.1 million

Total cost for manufacturing the gelatin = **US$** 0.5million

Profitability per annum = {Total sales – Total Cost}

= US$ 0.6 million

9.5. Leather board manufacturing

Environmental responsibility is the contemporary consciousness in industrial production and its effect is the main reason for the development of technology. This production approaches are undoubtedly the point of origine best practices for eco-benign production necessarily based on sustainability and green progresses. The wastes from leather industry need to be addressed for the sustainability which are involving both the inorganic and organic pollutants spoils the aquatic life, soil quality and atmospheric conditions. Of them fibrous wastes are of main importance in terms of their disposal properly and economically and especially wastes produced in shaving process have a great value for utilizing in composite material production.

Solid wastes from tanning industries have become an important environmental problem because of their toxic contents and inadequate waste management. The solid wastes generated from leather industry is a recent agenda because of their volumes and very limited recovery practices. The fibrous cut-out solid wastes, namely shavings, are toxic for environment and in case of oxidation to hexavalent form their disposal requires extreme cautions. Considering the amount of such wastes, methods such as recycling and re-use of trivalent chromium are not practicable. The existing methods such as incineration and pyrolysis are not good choices because they cause harmful gase emissions. Therefore; the reuse of wastes in the production of composite materials is regarded as an issue to be highlighted in terms of environmental and health care.

Considering the environmental sustainability, chromium shavings as fibrous leather wastes were used as reinforcement fragments in polymeric matrices for composite applications. Such products having similar properties to the leather are suitable for various applications such as shoe parts and some customer goods, and the properties can be developed in liaison with the demands as a composite basis for some fields.

Leatherboard is a kind of composite made of natural fibers that adhere together and bonded through appropriate binders. It is an old technologic background. However; there recently need to be incorporated many innovations into this technology in terms of performance requirements. Fibers and binders are of main importance on the improvements of characteristics, thereby; complying with expectations.

New regeneration of texture having been simulated to leather are executed to comply with the integrity in mechanical behaviours. The best solution is the use up this huge volume of wastes after converting them into any serviceable material. Regenerated materials having leather-like properties are both going for the demands in many fields and requirement for removal them in terms of sustainability and competitiveness.

In order to convert the fibrous wastes into harmless form and, exclude them from waste by valorization in possible usages; the production of composite materials so-called leatherboard is a basic sustainability approach for the leather industry. Shifting to the practice of this approach yields in various material types with appropriate mechanical strength and efficient performance characteristics for different applications.Leatherboards is an engineering product serving as a model of the approach from the waste to high value added material in which leather wastes are being used.

Leatherboard processing is the formation of a compound with leather fibers, non-leather fibers and binders appropriately. It deals with the preparation of a stabilized dispersion, spreading out on a band to be a continuous sheet and getting stuck on a material with an integrity. Even though fibrous wastes including shavings and others as well as binders and surface active agents are main components in leatherboard production, several processing auxiliaries such as; crosslinkers, softeners, retention and drainage aids, water repellents, antifoaming agents, dispersants, chelating agents, coagulants all are quality-dependent factors. This processing auxiliaries have certain functions for preparation of a dispersion with tiny particles ground to 1-2 mm, subsequently wet-laid period and dry sheeting. Figure. 17 shows the process outline symbols schematically of leather board manfacturing

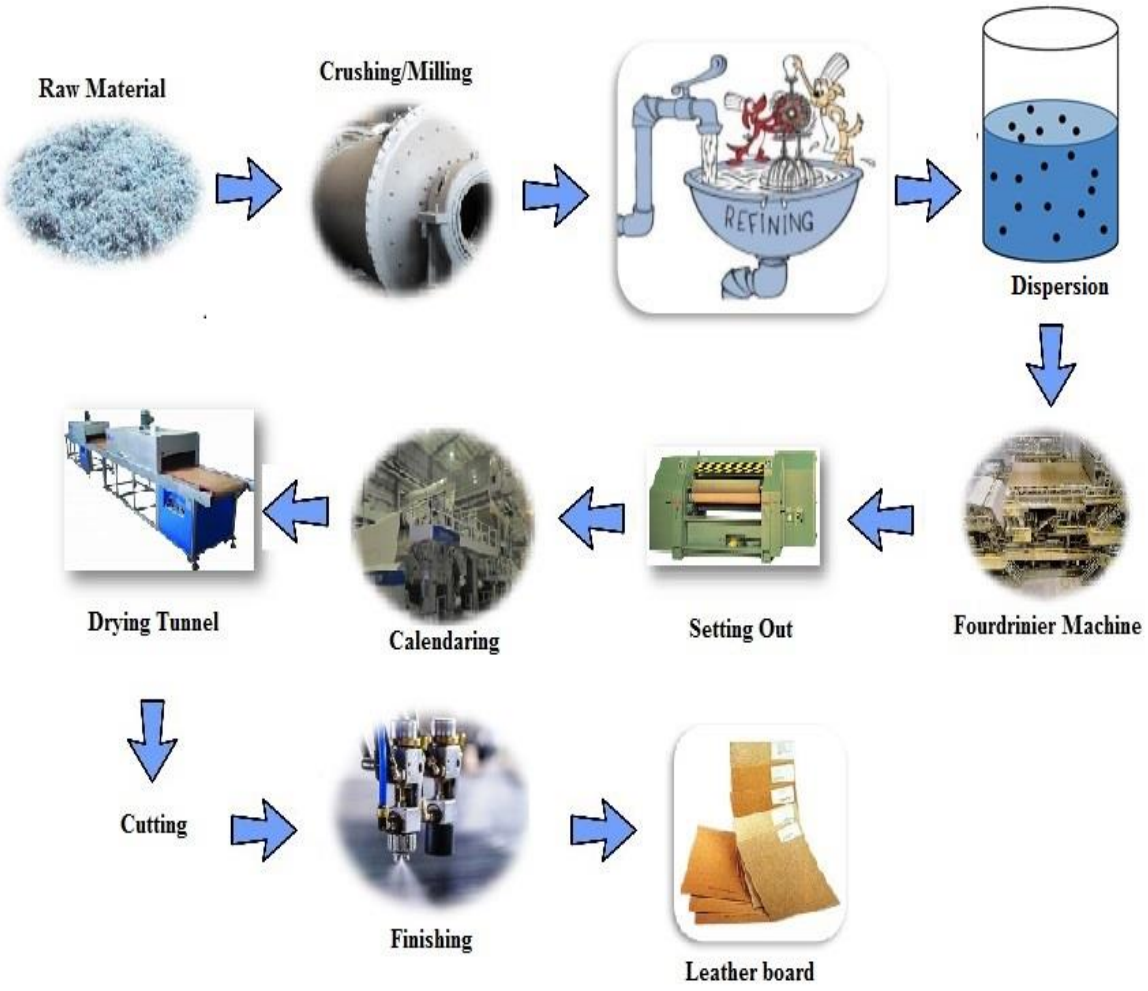

Figure 17. Leatherboard manufacturing process outline

Their characteristics being at the forefront is their fibrous texture and of course the fact that the shaving wastes in combination with other wastes is the feasible recovery option. Developing low cost composite materials for use in footwear, leather goods, household interiors, etc. from leather wastes is an efficient way of waste utilisation and environmental pollution prevention.

9.6. Compost from untanned tannery solid waste

Leather industry, one of the polluting industries, operations during the processing of leather release different types of pollutants (EPA, 2007) i.e. generation of huge amount of liquid and solid wastes, also emits obnoxious smell because of degradation of proteinous material of skin and generation of gases such as NH_3, H_2S and CO_2. There is considerable use of chemicals and water in the conversion of hides/skins into finished leather product and this generates a large amount of solid and liquid waste (Paul H et.al, 2013). These wastes will pollute the environment and pose threat on the health and wellbeing of human beings; if they are not well treated. Consequently, the treatment of pollution caused by the wastes from leather tanning is really important. In comparison with the disposal of leather wastewater, the treatment of leather solid wastes is more intractable.

The industry produces large amounts of solid organic wastes in the form of untanned (trimmings, fleshings, splits, hair) and tanned (trimmings, splits and shavings) waste generated from raw hides and skins, semi-processed leather, as well as sludge as a result of wastewater treatment (Buljan, J,2000). Animal fleshing is the predominant proteinous solid waste generated during processing of leather and it is confronting disposal problems. Hence, the treatment of leather solid wastes needs more improvements.

The Composting process

Principles of Composting: -Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions [12]. The composting process may be defined as the biological decomposition of biodegradable organic waste into simpler compounds under controlled aerobic conditions producing a stabilized and sanitized product that
is safe to use for agricultural purposes (Adani, F.et.al, 1997). Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting (FAO, 2013).

The process of composting depends on the activity of microorganisms such as bacteria, actinomyces,yeasts, mould and fungi to break down the organic compounds into simpler substances, which can exist in the material to be composted or added to it. Those microorganisms account for organic matter decomposition. In order to live and develop its decomposition activity, optimal

conditions of temperature, moisture and oxygenation are required (National Resource Conservation Services, 2007). Composting is a viable process of treating solid waste for beneficial use and destroying pathogens, diseases and undesirable weed seed. Composting generates a considerable amount of heat; carbon dioxide and water vapor are released into the air.

Composting Process Description: - The composting process has four composting phases that are defined according to the temperature, which is directly proportional to the biological activity within the composting process. Temperature is the principal parameter that controls microbial activity during composting (Stentiford, E.I., 1996). As the metabolic rate of microorganisms accelerates the temperature within the piles increases, then the temperature is a function of the accumulation of heat generated metabolically, and simultaneously the temperature is a determinant of metabolic activity. The interaction between heat output and temperature is the centerpiece of rational control of the composting process.

The four composting phases are summarized as below.

- **Mesophilic Phase (25–40 ^{0}C)**

The initial phase of the composting process in which at ambient temperature, mesophiles microorganisms rapidly multiply in vegetable mass. Energy-rich, easily degradable compounds like sugars and proteins are abundant and are degraded by fungi, actinobacteria, and bacteria, generally referred to as primary decomposers. Provided that mechanical influences (like turning)
are small, also compost worms, mites, millipedes, and other mesofauna develop, which mainly act as catalysts[18].As a result of metabolic activity, temperature increases and organic acids are produced.

- **Thermophilic Phase (35–65^{0}C)**

Organisms adapted to higher temperatures get a competitive advantage and gradually, and at the
end, almost entirely replace the mesophilic flora. Previously flourishing mesophilic organisms die off and are eventually degraded by the succeeding thermophilic organisms, along with the remaining, easily degradable substrate.

The decomposition continues to be fast, and accelerates until a temperature of about 62^{0}C is reached. Thermophilic fungi do have growth maxima between 35 and 55^{0}C, while higher temperature usually inhibits fungal growth. Thermotolerant and thermophilic bacteria and action
bacteria are known to remain active also at higher temperatures.

The same temperatures are not reached in all zones of a compost pile; thus, it is important that, through regular turning, every part of the substrate is moved to the central, hottest part of the pile. From a microbiological point of view, four major zones may be identified within a pile. The zone is the coolest, and well supplied with oxygen; the inner zone is poorly supplied with oxygen; the lower zone is hot, and well supplied with oxygen; while the upper zone is the hottest zone, and usually fairly well supplied with oxygen. The thermophilic phase is important for hygienization. Human and plant pathogens are destroyed; weed seeds and insect larvae are killed. The disadvantage of temperatures exceeding 70^0C is that most mesophiles are killed, and thus the recovery is retarded after the temperature peak (L.F. DIAZ.et.al, 2007).

- **Cooling Phase (Second Mesophilic Phase)**

It is characterized by a decrease in temperature as the microbial population/ thermophilic organism's drops due to reduction of readily available organic substrates. Mesophilic organisms
recolonize the substrate, either originating from surviving spores, through spread from protect edmicroniches, or from external inoculation. While in the starting phase organisms with the ability to degrade sugars, oligosaccharides and proteins dominate, the second mesophilic phase is characterized by an increasing number of organisms that degrade starch or cellulose. Among them are both bacteria and fungi (L.F. DIAZ.et.al, 2007).

- **Maturing**

The final product of composting is a stabilized and sanitized organic matter with humic characteristics [6]. Humus is the product of the humification process during which compounds of
natural origin are transformed into inert humic substances [14]. During the maturation phase, the quality of the substrate declines, and in several successive steps the composition of the microbial community is entirely altered. Usually, the proportion of fungi increases, while bacterial numbers decline. Compounds that are not further degradable, such as lignin–humus complexes, are formed and become predominant (L.F. DIAZ.,2007).

Process Drivers

As in any biological process, the factors affecting composting are of several types: environmental conditions, type of waste to be treated and composting technique. Permanent monitoring and control of these factors is of the highest importance (BCMAF, 1996).The principal environmental conditions are dependent on temperature, moisture content, oxygen, and pH.

Since composting is a biological process carried out by microorganisms, parameters affecting their growth and reproduction should be taken in to account. These factors include temperature, pH, C/N ratio, oxygen, or aeration and the substrate moisture. Externally, the composting process largely depends on environmental conditions; the method used, raw materials, and other elements, so that some parameters may vary. However, they must be under constant surveillance to always be within an optimal range (Roman P, et.al, 2015)..

Compost preparation process from tannery untanned solid wastes and admixtures:

I. Material Characterization

As quality of the raw material has its own impact on the quality of the final compost, it is useful to evaluate the composition of the tannery untanned solid wastes and admixtures for proper treatment during the composting process (AhmedM,2007). Parameters will also analyze after completing composting process.

A representative portion of the collected samples will be analyzed following standard methods (AhmedM,2007). in a numerous of parameters, including pH, moisture content, conductivity, OrganicCarbon (OC), total Kjeldahl Nitrogen (TKN),Total Phosphorus, Total Potassium, Micronutrients/heavy metals and Phytotoxicity test.

pH and electrical conductivity (EC) - a suspension will be made in a flask by mixing sample with distilled water (1:5 w/v). The pH of the sample will be determined, using pH meter (ADHI) and electrical conductivity will be determined, using a conductivity meter (HI 2300 EC/ TDS/NaCl meter) HANNA Instrument [Crohn, D.M., 2016]. N will determined by micro-Kjeldhal method (Bremner JM et.al,1982) and Total Phosphorus will determine using Sodium Hydroxide fusion method.

The moisture content will be determined using the gravimetric method and dry combustion method of (Nelson, D.W, 1982) is used for determining the OC; C/N ratio can be computed from the measured values of C and N.

The contents of the mineral elements for Zinc, Copper, Chromium, Cadmium, Manganese, Lead, Cobalt and Potassium will be determined using the ISO 17072-2:2015 standard method and analyzed by ICP-OES spectrometers. The phytotoxicity of compost extracts will be evaluated by the seed germination technique (Tam, N. F, 1994).

II. Collection and Preparation of samples

The tannery untanned solid wastes used are collected from tanneries. While, bulking agents, organic wastes and inoculums can be obtained from the market. The materials and the quantity of the samples were determined keeping in mind the difficulties that the wastes present for example, fleshing waste is alkaline. - As a consequence untanned solid wastes /admixtures were in the ratio of 1:1. The mixture will be prepared in order to optimize the composting parameters, that is, 50 - 60% humidity and a C/N ratio of about 30:1. Composting process will be lasted for three months or takes 90 days.

III. Preparation of Compost

Composting is carried out a compost pile under a tree shade, with a stone floor. The composting time last for about 90 days. A known quantity of tannery untanned solid waste and admixtures mixed in a suitable ratio without compression in order to retain air inside. As inoculums, a stable and very active population of commercial microorganisms can be introduced. The quantity
to be applied will be as per supplier recommendations. The mixture will be prepared so as to maintain the composting parameters, i.e., 50- 60% humidity and a C: N of 25-30:1. Mixing may
be needed for the pile to be homogeneously processed. With the aim of maintaining aerobic conditions during the process, the pile will be turned manually every 15 days. The following process will show Composting of Organic Waste.

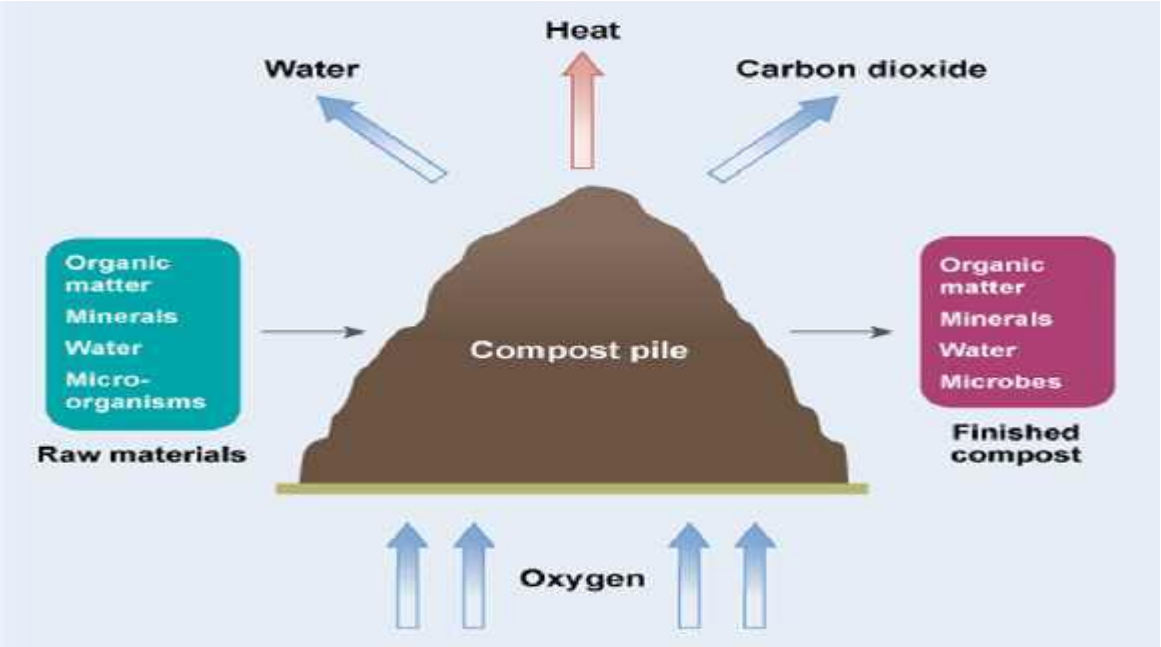

Figure 18: Composting of Organic Waste

9.7. Production of glue from hide lime trimming

Glue is an adhesive substance used for sticking objects or materials together or any substance applied to the surfaces of materials that binds them together and resists separation. It is sold as coarse powders, granules and cakes or plates. Hide glue is a polymer derived from hide collagen by extraction with heat in the presence of water and it has its own physical, chemical and mechanical properties. It is used chiefly in industrial applications as an adhesive in wood working, paper, leather, shoes, belt, textile, abrasive and it is also graded based on quality parameters like viscosity, jelly strength etc. From the total tannery wastes up to 56-60% is the lime trimming/fleshing waste. 8-10 kg/hide piece or an average of 0.375kg/kg skin trimming solid waste is generated. These solid wastes can be converted in to valuable products like glue gelatin, protein filler, fertilizer etc.

The major process to be carried out in this production are: preparation of extraction set up, collection and preparation of raw materials and chemicals required, performing extraction, concentration/reduction of moisture, sizing of the glue in to required pieces, drying, quantify the yield and the residue releasing, characterization/tests quality parameters of glue like jelly strength, viscosity, moisture content, pH and ash content.

9.8. Power Production through Biogas from solid wastes

Based on the data of the produced from tanners found in Modjo , the company from Germany had proposed waste to energy technologies with cost estimates as shown below used as reference for further project implementation.

Table 23. Tanneries waste types with amount solid waste produced in Modjo areas per annum basis

Tanneries waste types with amount solid waste produced in Modjo areas per annum basis	Tannery Average	Germany Company, Rehau (55% average)
1.Raw hide trimming: 2000 -3000 ton	2500 t/a	1375 t/a
2.Fleshing and pelt trimming: 6000-10000 ton	8000 t/a	4400 t/a
3.Chrome shaving :1200-1600 ton	1400 t/a	770 t/a
4.Chrome trimming and finished leather pieces :500-600 ton	550 t/a	303 t/a
5.Buffing dust :100-200 ton	150 t/a	83 t/a
6. ETP sludge: 21000 ton with 30% dry solid content	21000 t/a	11550 t/a

Solids within the ETP sludge	6300 t/a	3465 t/a
Hides/ skins	50000 t/a	27500 t/a

The company describes, If it can use this waste completely in one TanERGY installation, it will have these results:

Table 24. TanERGY installation company solid waste consumption

Solid wastes types	Average	Total dry solids	
1.raw hide trimming 2, 000-3,000 tons	1375 t/a	50%	688 t/a
2.fleshing and pelt trimming ,6000-10,0000 tons	4400 t/a	35%	1540 t/a
6. ETP sludge 21,000 ton with 30% dry solid content	11550 t/a	30%	3465 t/a
Total without chrome	17325 t/a	33%	5693 t/a
Biogas potential	11.954 MWh/a		
Power production potential from biogas	4.782 MWh/a	546 kW	

3.Chrome shaving 1,200-1,600 tons	770 t/a	50%	385 t/a
4. Chrome trimming and finished leather pieces 500-600 tons	303 t/a	80%	242 t/a
5.Buffing dust :100-200 tons	83 t/a	100%	83 t/a
Total with chrome	1155 t/a	61%	710 t/a
Biogas potential	1.277 MWh/a		
Power production potential from biogas	511 MWh/a	58 kW	

If we look at the non-chrome substances initially, a suitable TanERGY® installation would consist of:

- The pre-treatment of the trimmings and fleshings (mincer, heater, centrifuge)
- A buffer tank for the treated organics
- A digester ø22m x 7.5m high with gas buffer roof
- A post-digester / digestate buffer ø22m x 7.5m high with gas buffer roof
- Biogas purification
- A 635 kW cogeneration unit (as we have two of them at the Südleder installation)
- An automation container

If TanERGY would provide the engineering, project and site supervision and would supply, install and commission the technical equipment, our cost would be appr. 3.5 Million EURO. The civil engineering including the tanks would have to be provided locally.

Like wise even if there is no detial manfturing process; there are many kind of solid wastes (particularly the proteinous wastes) is an economically lucrative solid waste management option. Some of the viable products are listed below:

I. Syntan from trimming and hair waste
II. Chicken feed from fleshings
III. Manufacture of activated carbon from fleshings
IV. Regenerated hide from chrome free leather waste
V. Synthetic leather from dye staff containing leather wastes
VI. Retainning agent made from collagen protein
VII. Ultra-fine leather powder from dyestuff-containing leather waste

Finally after all the solid wate by proucts are produced , the remain wastes and sludge wastes from the treatment has to be dischrage to the landfill system having all the leachte treatment facilites .

9.9. Landfill

The management of solid wastes and by-products is vital to ensure economic and environmental sustainability to a tannery district. The identified long term strategy is aimed at reducing the production of solid wastes through recovery of materials and transforming into valuable products. This approach will ensure minimization of carbon footprint for the overall industrial processes through the recovery of organic compounds and nutrients (mainly nitrogen) and, at the same time, through implementation of state-of-the-art waste transformation technologies that will convert potential waste management costs into marketable products.About 60% of the total solid waste production can be recovered and transformed. However, the implementation of the wastes transformation facilities will require time. As a consequence the landfill design takes into consideration all kinds of solid wastes generation from tanneries found in Modjo town until the implementation of all proposed solid wastes utilizatioin strategies. After solid wastes (by products) of the taning process are manged, the secure land fill would be used for wastes having low total organic carbon like sludges.

10. Environmental Monitoring Programme

Monitoring is a cornerstone of impact assessment implementation and follow up. Monitoring is an essential component for sustainability of any industrial operation. It is an integral part of any environmental assessment process. Any operating tannery introduces complex interrelationships between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is difficult to predict with complete certainty the exact operation phase environmental scenario. Hence, monitoring of critical parameters is essential in the tanning operation phase. Other components are dependent on the scope and type of monitoring information that is provided. The primary aim of monitoring is to provide information that will help impact management, and secondarily, to achieve a better understanding of cause-effect relationships and to improve impact prediction and mitigation methods. Both the immediate and long-term benefits from undertaking monitoring as part of impact assessment are widely recognized. Monitoring will be used to:

- measure the impacts that occur during operation of the tanneries ;
- check their compliance with agreed conditions and standards;
- facilitate impact management, e.g. by warning of unanticipated impacts; and
- Determine the accuracy of impact predictions and the effectiveness of mitigation measures.

Monitoring of environmental indicators signal potential problems and facilitate timely prompt implementation of effective remedial measures. It also allow for validation of the assumptions and assessments made in the present study. Monitoring becomes essential to ensure that the mitigation measures planned for environmental protection function effectively during the entire period of tanneries operation.

10.1. Surface and Ground Water Quality

Chemical characteristics of effluent shall be monitored by tanneries on daily basis, weekly or monthly based on the kind of parameters to be tested to control the treatment performance. Chemical characteristics of select parameters like pH and the flow rate of the effluent inlet and the effluent outlet from the ETP shall be carried out on daily basis. The Physico- chemical and biological/microbiological characteristics of surface and ground water quality shall be monitored

biannually. The parameters to be monitored are as follows:

Industrial Effluent Flow (per hour and per day) Physico-chemical Characteristics

- Temperature
- pH
- BOD5 at 200 C
- COD
- Suspended solids
- Total ammonia as N
- Total nitrogen as N
- Total phosphorous as P
- Oils, fats and grease
- Mineral oil (interceptor)
- Chromium as total Cr
- Chromium as Cr(VI)
- Chloride (as Cl-)
- Sulfide
- Phenols

Surface and Ground Water

Physico-chemical Parameters: pH, Salinity, Conductivity, TDS, Turbidity, D.O., BOD, Phosphates, Chromium, Nitrates, Sulphates, Chlorides.

Biological/Microbiological Parameters: Phytoplankton (No. of species and their density), Zooplanktons (No. of species and their density), Total Coliforms (TC), and *E. coli*.

10.2. Solid waste monitoring

The tanneries shall monitor the types and quantity of solid waste generated on daily basis.

10.3. Air and Noise monitoring

The air quality (SO_2, CH_4, CO, CO_2. Nox, VOC, PM $_{2.5}$, PM_{10}, H_2S and NH_3) and noise level at different sections of the tannery shall be checked based on the nature of the process or operation. The air and noise shall be monitored once per year.

10.4. Summary of Environmental Monitoring Program

The summary of Environmental Monitoring Program for tannery operation is in table 19 shown below.

Table 25: Summary of environmental monitoring program for the operation of tanneries

S/N	Aspects	Parameters to be monitored	Frequency of monitoring	Location
1	**Industrial effluents**			
	Physico-chemical parameters	Flow rate, pH, Total Dissolved Solids (TDS), Sulphide	Daily	At inlet and outlet of ETP
		Suspended Solids (SS), COD, BOD	Weekly	At inlet and outlet of ETP
		Oil & Grease, Total Kjeldahl Nitrogen, Ammoniacal Nitrogen (as N), Total	Monthly	At inlet and outlet of ETP
		Cr+6, Total Phosphorus, P, Phenols	Quarterly	At inlet and outlet of ETP
2	**Surface and ground water**			
	Physico-chemical parameters	pH, Salinity, Conductivity, TDS, Turbidity, D.O., Phosphates, Nitrates, Sulphates, Chlorides, Hardness,	Biannually	From the available bore hole and two places for surface water (upstream and downstream)
	Biological & Microbiological	Phytoplankton (No. of species and their density), Zooplanktons (No. of species and their density), Total Coliform (TC), *E. coli*	Once in a year	
3	**Ambient air quality**	PM_{10}, SO_2,Co, Co_2,VOC, NO_2, CH_4 from land fill	Once in a year	Different places of the factory
4	**Noise**	Equivalent noise level	Once a year	Different places of the factory
5	**Solid waste**	Monitor the type and quantity of solid wastes	Daily	Different section of process
6	**Green belt**	Rate of survival and growth of various species	Once per month	Around plant site

10.5. Cost estimate

The cost required for implementation of Environmental Monitoring Program during tanneries operation at the Modjo town is 2,208,000.00 Birr (Table 22).

Table 26: The cost required for implementation of Environmental monitoring program for tanneries found in Modjo

S.N	Parameter	Annual cost (Birr)
1	Effluent (inlet and outlet at ETP)	648,000.00
2	Surface and ground water	120,000.00
3	Ambient air quality including noise	360,000.00
4	Solid waste	720,000.00
5	Green belt	360,000.00
	Total	**2,208.000.00**

11. Conclusion and Recommendations

11.1. Conclusion

This document generally attempted to show the environmental impact and controlling measures of tanning industries found in Modjo town. The tanneries and regulatory bodies are expected to follow suggested mitigation measures to control all the impacts associated with the operation of the tanning industries.

According to the key informant discussion, the tanning industries found in Modjo town caused negative health and environmental impact, while it has major benefit for the community in provision of employment opportunity and creating other allied business with the sector.

Those environmental and social impacts can be managed and reversed by the tanneries, environment regulator bodies, communities and other relevant stakeholder through proper interventions. Likewise, the proposed mitigation measures to reduce significant environmental impacts are measureable, reversible and manageable. Therefore, the anticipated environmental and social impacts can be avoided or minimized to very insignificant level by just implementing the environmental management plan and monitoring program described in the impact assessment document.

11.2. Recommendations

To enhance potential benefits and social acceptability of the tanning industries , avoiding or minimizing adverse impacts of the tanners is recommended. Also, the proposed mitigating measures need to be implemented in time scheduled. To ensure proper implementation of environmental management plan, continuous monitoring and internal audit are important for environmentally friendly operation of the tanneries. In addition, the company should create harmonious relationship with the local community by holding regular discussions with local elders so as to develop trust and to avoid unexpected conflicts. In collaboration with the local government and the affected community, the tanneries are recommended to support development efforts as deemed necessary. Below are recommendations suggested by the consultant.

- To enhance the potential economic benefits and social acceptability of the tanning industries; the tanners (a) should avoid or minimize any adverse impacts of their operation on human health and, (b) should reduce adverse impacts on the environmental resources,
- Support awareness creation and trainings programs for local community and experts on environment,
- Effluents need be segregated and treated separately. This means liquid and solid wastes should be treated and disposed of at appropriate site,
- Tanning industries have to employee the professional and skilled experts who are responsible to operate ETPs and to monitor the environmental management systems of the tanneries.
- Conduct regular monitoring and reviewing of the impacts and analysis of potential impacts in advance in order to avoid potential damages and public complaints.
- Undertake continuous identification of risks on environment, occupational health and safety and implementation of risk management systems;
- Prepare the environment and social responsibility policy
- Formulate emergency preparedness and response program,
- Undertake stakeholders' engagements; transparent and reoccurring discussions with the affected communities and employees;
- Study of the Modjo river profile at four different seasons so as to determine the pollution loads at different time frames.

- Harmony relationship shall be developed with local communities to develop confidence in the tanning industries.
- Support development efforts of local communities in the Modjo town. This will strengthen ties between the tanners and local people.
- The tanners shall be regulated by the established social and environmental principles and occupational and health safety rules to comply with national and international obligations by the respective environmental, and labour authority

In general, it is recommended that the tanners shall be clustered with common facilities like CETP, secured landfill and solid waste recycling facilities to create a sustainable leather sector by alleviating their bottlenecks related to environmental issues. Therefore, the consultant insists the local, regional and federal offices to give due attention to implement the Modjo Leather City project with in short period of time.

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Annex I. Checklist

This checklist is used to analyze the impact of tanneries on Modjo town: In this checklist the following points are included: Those are: baseline information, Environmental impact (liquid waste management and solid waste management), social impacts and Environmental impacts.

1. Baseline Information [4]

No	Category	List of baseline of Modjo Town
1	**Physical Environment**	• Temperature (minimum and maximum ranges temperature in tanning areas)
		• Humidity (monthly relative humidity)
		• Rainfall (Average rainfall)
		• Wind speed
		• Sunshine hours (amount of solar radiation received on a given surface area)
		• Water resources (surface and ground waters)
		• Water quality assessment
		• Soil (dominant textural class)
		• Landscape and Topography (relief elevation ranges in m.a.s.l.)
		• Hydrology
2	**Biological Environment**	• Vegetation and wild life (Common plant species found around the study area)
3	**Social and Economic Environment**	• Social Services(health services and educational centers)
		• Infrastructure
		• Communication
		• Tourism
		• Business linkage with the sector
		• Employment by the sector (No of employee by the tanners)

[4] *The baseline of the Modjo town addressing all the physical, biological and socio-economic aspects were taken*

2. Environmental Impact

2.1. Liquid Waste Management

For what purpose are the water discharged from the effluent treatment of the tanneries are in use?

_____

_____

How much total water do the tanners consume per month (m^3/month or liter/day)

_____

_____

How much the liquid waste does the sector generating per day (m/day^3)

_____

_____

How often do you monitor the discharge treated waste water from tanneries?

_____

_____

Local authorities that approved handling of wastewater from tanneries

_____

_____

_

2.2. Solid waste management

What type of solid waste does the Modjo town facilities are producing?

_____

_____

No	Tannery Solid wastes	Glass containers , Tin cans	E-waste	Batteries	Paper waste	Plastic waste	Used tires	Canteens waste	Construction Debris and Demolition Wastes

Others, specify_____

Estimated average weekly/ monthly quantity of regulated of each waste

.No	Tannery solid waste	Glass containers , Tin cans/kg/week	E-waste	Paper waste	Plastic waste	Used tires	Canteens waste	Construction Debris and Demolition Wastes

Or no any record keeping on generation of solid waste from the city

_____

Is the solid waste containers properly labeled? and placed in an appropriate place?

_____

_____

Who is responsible to collect the solid waste?

_____
_____

Was operational solid waste collection, transportation, storage, recycling or disposal method exists?

_____
_____
_____

If you did not have a solid waste collector, where did you dispose?

_____
_____

What are the man challenges you faced regarding solid waste management?

_____
_____
_____

Service agreement, if collection and/or treatment is outsourced?

_____
_____

Do you have any chemical based solid wastes (hazardous) ?

_____
_____

Do transportation vehicles and containers meet requirements for safety outlined in proclamation?

_____

3. Social Impact

Is there any registered complaint from the society? Please list down in a tabular form.

S.No.	Name of Compliant	Address/institution of Compliant	Types of compliant	Registration number	Decision made

Is there any medical reports from the health centers, veterinary clinics, agriculturalists related to the impact of Modjo river and open disposal site pollution by tanning industries?

_____

_____

Is there any bad nuisance odor complain from the society?

_____

_____

Is there any damages caused due to tanning industries, in terms of cultural heritages, ecological balances and economic activities?.

_____

_____

4. Economic impacts

How much is the export earnings of the tanning industries found in Modjo?

_____

_____

How many employees are working in leather sector found in Modjo?

_____

_____

How many small and medium enterprise are linked with the tanning industries found in Modjo?

_____

_____

How much is the tanning industries tax revenue collected from tanning industries found in Modjo?

_____

_____

Is there any economic damage cost estimation on agricultural activities like farming, cattle rearing due tanning activities in Modjo?

_____

_____

Annex II. Major stakeholder interviewed

No	List of key informants	Interviewee	Address	Remark
1	Modjo Town Administration			
2	Modjo Town Land Management Office	Mr. Kebede Abera	Modjo	
3	Modjo Town Environment, Forest and Climate change Authority office	Mrs. Senait Megera and Ms. Jiratu Daba	Modjo	
4	Modjo Town Finance And Economy Office			Modjo town Profile
5	Mojo Town Health Office	Mr. Tulu Bedada		General Director
6	Group Of Farmers	1.Mr. Sori Feyessa	0920367690	
		2.Mr. Terefe Fafa		
		3.Mr. Rorisa Raya		
		4.Mr. Lemi Debele	0912235925	
		5.Mr. Shebru Chochele	0912813465	
		6. Tufa Degefe	0910779891	
7	Residents Close To The Tanneries			
8	Solid Waste Collectors			
9	Glue Manufactures			
10	Animal Herders			

Annex III. Laboratory test results

ADDIS ABABA WATER & SEWERAGE AUTHORITY
WATER QUALITY CONTROL SERVICE
P.O.BOX 1505, TEL.0116-621496/622919
PHYSICO-CHEMICAL WATER QUALITY ANALYSIS REPORT

Analysis requested by: **Prospect Consultancy**
Source of sample: **Ground Water**
Sampling site: **Modjo, Oromia Region**

Date of sampling: **27/09/2021**
Date of analysis: **04/10/2021**
Sampled by: **Prospect Consultancy**

S.No	Parameters	Unit	CODE-6	WHO
1	Turbidity	NTU	0.23	<5
2	Odor	Non obj.	Non obj.	Non obj.
3	Taste	Non obj.	Non obj.	Non obj.
4	PH	-	7.1	6.5 - 8
5	Total Dissolved Solid(TDS)	mg/l	898	600
6	Electrical conductivity(EC)	µS/cm	1821	-
7	Total Alkalinity as $CaCO_3$	mg/l	393.2	-
8	Total Hardness as $CaCO_3$	mg/l	506.6	-
9	Calcium Hardness as $CaCO_3$	mg/l	418.8	-
10	Magnisium Hardness as $CaCO_3$	mg/l	87.8	-
11	Ammonia as N	mg/l	0.3	1.5
12	Nitrite as N	mg/l	0.006	1
13	Nitrate as N	mg/l	2.4	11
14	Sulfate as SO_4	mg/l	80	250
15	Phosphate as PO_4	mg/l	0.52	-
16	Fluoride as F	mg/l	1	1.5
17	Total iron as Fe	mg/l	0.05	0.3
18	Manganese as Mn	mg/l	0.063	0.1
19	Silica as SiO_2	mg/l	65	-
20	Chloride as Cl	mg/l	299	250
21	Bicarbonate alkalinity as HCO_3	mg/l	393.2	-
22	Carbonate Alkalinity as $CaCO_3$	mg/l	Nil	-
23	Hydroxide Alkalinity as $CaCO_3$	mg/l	Nil	-

Analysed by: Agerito Gobeze
Chemist

Approved by:
Solomon Tadesse
Catchment Management and Water Quality Control Case Manager

ADDIS ABABA WATER & SEWERAGE AUTHORITY
WATER QUALITY CONTROL SERVICE
P.O.BOX 1505, TEL.0116-621496/622919

PHYSICO-CHEMICAL WATER QUALITY ANALYSIS REPORT

Analysis requested by: **Prospect Consultancy**
Source of sample: **Ground Water**
Sampling site: **Modjo, Oromia Region**

Date of sampling: **27/09/2021**
Date of analysis: **04/10/2021**
Sampled by: **Prospect Consultancy**

S.No	Parameters	Unit	CODE-7	WHO
1	Turbidity	NTU	2.13	<5
2	Odor	Non obj.	Non obj.	Non obj.
3	Taste	Non obj.	Non obj.	Non obj.
4	PH	-	7.02	6.5 - 8
5	Total Dissolved Solid(TDS)	mg/l	**4180**	600
6	Electrical conductivity(EC)	µS/cm	7770	-
7	Total Alkalinity as $CaCO_3$	mg/l	349	-
8	Total Hardness as $CaCO_3$	mg/l	**4236**	-
9	Calcium Hardness as $CaCO_3$	mg/l	**2858**	-
10	Magnisium Hardness as $CaCO_3$	mg/l	**1378**	-
11	Ammonia as N	mg/l	**4.6**	1.5
12	Nitrite as N	mg/l	0.016	1
13	Nitrate as N	mg/l	8.2	11
14	Sulfate as SO_4	mg/l	**460**	250
15	Phosphate as PO_4	mg/l	0.43	-
16	Fluoride as F	mg/l	1.14	1.5
17	Total iron as Fe	mg/l	0.13	0.3
18	Manganese as Mn	mg/l	**0.224**	0.1
19	Silica as SiO_2	mg/l	58	-
20	Chloride as Cl	mg/l	**612.75**	250
21	Bicarbonate alkalinity as HCO_3	mg/l	349	-
22	Carbonate Alkalinity as $CaCO_3$	mg/l	Nil	-
23	Hydroxide Alkalinity as $CaCO_3$	mg/l	Nil	-

Analysed by: Agerit Gobeze
Chemist

Approved by:

Solomon Tadesse
Catchment Management and Water Quality Control Case Manager

City Goverment of Addis Ababa Addis Water & Sewerage Authority

ADDIS ABABA WATER & SEWERAGE AUTHORITY
WATER QUALITY CONTROL SERVICE
P.O.BOX 1505, TEL.0116-621496/622919

PHYSICO-CHEMICAL WATER QUALITY ANALYSIS REPORT

Analysis requested by: **Prospect Consultancy**
Source of sample: **Ground Water**
Sampling site: **Modjo, Oromia Region**

Date of sampling: **06/10/2021**
Date of analysis: **13/10/2021**
Sampled by: **Prospect Consultancy**

S.No	Parameters	Unit	CODE-8	WHO
1	Turbidity	NTU	0.511	<5
2	Odor	Non obj.	Non obj.	Non obj.
3	Taste	Non obj.	Non obj.	Non obj.
4	PH	-	7.07	6.5 - 8
5	Total Dissolved Solid(TDS)	mg/l	651	600
6	Electrical conductivity(EC)	µS/cm	1344	-
7	Total Alkalinity as $CaCO_3$	mg/l	363.6	-
8	Total Hardness as $CaCO_3$	mg/l	522.8	-
9	Calcium Hardness as $CaCO_3$	mg/l	484.4	-
10	Magnisium Hardness as $CaCO_3$	mg/l	38.4	-
11	Ammonia as N	mg/l	0.39	1.5
12	Nitrite as N	mg/l	0.009	1
13	Nitrate as N	mg/l	1.8	11
14	Sulfate as SO_4	mg/l	43	250
15	Phosphate as PO_4	mg/l	0.35	-
16	Fluoride as F	mg/l	1.5	1.5
17	Total iron as Fe	mg/l	ND	0.3
18	Manganese as Mn	mg/l	0.07	0.1
19	Silica as SiO_2	mg/l	67.5	-
20	Chloride as Cl	mg/l	240.75	250
21	Bicarbonate alkalinity as HCO_3	mg/l	363.6	-
22	Carbonate Alkalinity as $CaCO_3$	mg/l	Nil	-
23	Hydroxide Alkalinity as $CaCO_3$	mg/l	Nil	-

ND: Not Detected

Analysed by: Mihret Mersha
Chemist

Approved by: Solomon Tadesse
Catchment Management and Water Quality Control Case Manager

ADDIS ABABA WATER & SEWERAGE AUTHORITY
WATER QUALITY CONTROL SERVICE
P.O.BOX 1505, TEL.0116-621496/622919

PHYSICO-CHEMICAL WATER QUALITY ANALYSIS REPORT

Analysis requested by: **Aklilu**
Source of sample: **well**
Sampling site: **mojo**

Date of Sampling: **14/05/2012**
Date of analysis: **28/05/2012**
Sampled by: **Aklilu**

S.No	Parameters	Unit	Sample	WHO
1	Turbidity	NTU	0.722	<5
2	Odor	Non obj.	Non obj.	Non obj.
3	Taste	Non obj.	Non obj.	Non obj.
4	PH	-	6.64	6.5 - 8
5	Total Dissolved Solid(TDS)	mg/l	318	600
6	Electrical conductivity(EC)	µS/cm	657	-
7	Total Alkalinity as $CaCO_3$	mg/l	52.2	-
8	Total Hardness as $CaCO_3$	mg/l	192.8	-
9	Calcium Hardness as $CaCO_3$	mg/l	114.2	-
10	Magnisium Hardness as $CaCO_3$	mg/l	78.6	-
11	Ammonia as N	mg/l	0.04	1.5
12	Nitrite as N	mg/l	0.003	1
13	Nitrate as N	mg/l	0.6	11
14	Sulfate as SO_4	mg/l	8	250
15	Phosphate as PO_4	mg/l	0.81	-
16	Fluoride as F	mg/l	1.1	1.5
17	Total iron as Fe	mg/l	0.01	0.3
18	Manganese as Mn	mg/l	0.022	0.1
19	Silica as SiO_2	mg/l	54	-
20	Cnloride as Cl	mg/l	2.5	250
21	Bicarbonate alkalinity as HCO_3	mg/l	52.2	-
22	Carbonate Alkalinity as $CaCO_3$	mg/l	Nill	-
23	Hydroxide Alkalinity as $CaCO_3$	mg/l	Nill	-

Analysed by: Biniam Ketema
Chemist

Approved by: Solomon Tadesse
Catchment Management and Water Quality Control Case Manager

Amended Test report

Test date(s) : 07/09/21 – 06/10/2021
Lab. Design .Code No: WW-16745 to WW-16757
Type of Sample: Waste Water
Sample Identification:_____
Sampling Condition:_____
Sample Storage and Preservation: APHA 1060 C
Environmental test Condition: Temp.20.4 (^{0}C) & RH 67.3(%)

Report No: WW-16745 to WW-16757/21
Test order No: LIDI/001/21
Sampling Date & Place: Customer
Sampling location :See the attachement
Sample receiving date: 07/09/2021
Sampled by : Customer
Report date: 03/11/2021

Name of Customer: Prospect Consultancy
Address of customer: Tel : Office +251-912015178/+251-983980123
E-MAIL : anteneh2008@gmail.com
ADDIS ABABA, ETHIOPA

ORIGINAL

Customer code: See the attachment

S/No	Type of Test	Test Result	Unit	Test Method	Uncert ainty	Standard Required	Remark
1.	Chemical Oxygen Demand (COD)	Attached	mgO_2/l	APHA 5220-B	Attached	500.0	
2.	PH		-	APHA 4500-H+B	-	6-9	
3.	Total Suspended Solids as TSS		mg/l	APHA 2540 –D	-	50.0	
4.	Chloride (as Cl^{-1})		mg/l	APHA 4500-Cl^-B	-	1000.0	
5.	Sulfide (as S^{2-})		mg/l	SLC 202	-	1.0	
6.	Chromium trivalent (as Cr^{3+})		mg/l	SLC 208	-	--	
7.	Chromium Six (as Cr^{6+})		mg/l	SLC 22	-	0.1	
8.	Total Kjeldhal Nitrogen		mg/l	APHA 4500Org.	-	-	
9.	Total Nitrogen		mg/l	HACH LANGE LCK 138	-	60.0	

Remark : 1. The S.no. 2 -9 test parameters are not accredited
2. The Standard requirement is only for secondary out let & its from Ethiopian Environmental Protection Authority (EPA)
3. Samples independently collected delivered to the Laboratory by customer, Sample location described by customer
4. This test report is supplement to the test report number WW-16745 to WW-16757, reported on 06/10/2021 due to customer compliant and incorrectly stated the nitrogen result because of calculation error.

Tested By: Wudensh A. Chemical analysis Expert III — Signature
Checked By: Maereg H. Lead Chemical Analysis Expert (Team leader) — Signature
Authorized By: Berhan... Signature
Director, Research & Testing Laboratory Directorate

1. This test report is for technical information of the client only. Not for advertisement, promotion, publicity, litigation or legal purpose.
2. The test result relates only to the item tested.
3. Uncertainty calculated with expanding factor K=2 with confidence limit=95%
4. The test report must not be reproduced without approval of LIDI.
5. LIDI lab shall be indemnified against any dispute arising out of issue of this report

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Mobile +251-911 252713 elidilab@gmail.com
AKAKI -KALITY KEFLE KETEMA, ADDIS ABABA

LIDI	LEATHER INDUSTRY DEVELOPMENT INSTITUTE TESTING & RESEARCH LABORATORY DIRECTORATE	
Title	**Test report**	Page : 4 of 6

Amended Test Report

Attachment for Test Report

Type of samples	Lab. Design. code	Customer Code	COD (mg/l)	Uncer tainty	PH (mg/l)	TSS (mg/l)	Chloride (mg/l)	Sulphide (mg/l)	Chromium trivalent (mg/l)	Chromium six (mg/l)	Total Kjeldhal Nitrogen (mg/l)	Total Nitrogen (mg/l)
River	WW-16756	Lower river	104.7	±0.02	8.4	52.0	110.0	1.3	17.4	0.01	28.0	42.0
	WW-16757	Upper River	56.5	±0.12	7.6	20.0	95.0	0.9	8.7	0.01	28.0	40.0

Remark : 1. The S.no. 2 -9 test parameters are not accredited
2. The Standard requirement is only for secondary out let & its from Ethiopian Environmental Protection Authority (EPA)
3. Samples independently collected delivered to the Laboratory by customer, Sample location described by customer
4. This test report is supplement to the test report number WW-16745 to WW-16757, reported on 06/10/2021 due to customer compliant and incorrectly stated the nitrogen result because of calculation error.

Tested By: Wudensh A. Signature — Chemical analysis Expert III
Checked By: Maereg H. Signature — Lead Chemical Analysis Expert (Team leader)
Authorized By: Berha... Signature — Director, Research & Testing Laboratory Directorate

ORIGINAL

1. This test report is for technical information of the client only. Not for advertisement, promotion, publicity litigation or legal purpose.
2. The test result relates only to the item tested.
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4. The test report must not be reproduced without approval of LIDI.
5. LIDI lab shall be indemnified against any dispute arising out of issue of this report

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elidilab@gmail.com AKAKI -KALITY KEFLE KETEMA, ADDIS ABABA

Note:

- *Lower river and upper river stands for samples taken from lower and upper catchments of Modjo river*

JIJE LAB GLASS Pvt. Limited Company	JIJE Analytical *Testing* Service Laboratory	Doc. No: JATSL/F5.10-3.1	Page 1 of 1
		Ver. No: 04	Effective Date: July 08, 2017

Analytical Test Report

Customer Name:	Prospect Consultancy	Test Report No:	034
Contact Person:	Dr. Aysanew Gorems and Biniyam Fetene	Report Date:	17/11/2021
Sample Type:	Soil and vegetable	Test Request No:	Not Specified
Sample Source:	Modjo Areas	Tel (Mob):	+251911004676/911087964/912015178
Sample Collected By:	Anteneh Muheye	Fax:	Not Specified
Sample Collection Date:	02/11/2021	E-mail:	gorems@gmail.com/ bina85.b@gmail.com
Sample Receiving Date:	03/11/2021	Tested By:	JATSL
Sample Condition:	Normal	Dates Tested:	04/11/2021 To 15/11/2021

S/N		Customer ID	pH	Ec (mS/cm)	Results (%)		
					OM	TN	Moisture
1	J-0107/0311/21	Open Landfill	8.20	10.61	6.74	0.74	5.66
2	J-0108/0311/21	Modjo River side	8.90	1.21	1.48	0.16	6.78

S/N	Lab No	Customer ID	Results (mg/Kg)						
			Cu	Zn	Cr	Cd	Pb	TP	K
1	J-0107/0311/21	Open Landfill	443.08	166.42	7995.55	3.18	51.94	206.43	3126.99
2	J-0108/0311/21	Modjo River side	157.69	157.69	355.07	4.29	53.64	168.15	4451.83

S/N	Lab No	Customer ID	Results (mg/Kg)					
			Cr	Cu	Zn	Ni	Cd	Pb
1	J-0109/0311/21	Vegetable	22.17	2.50	12.17	1.50	ND	5.50

S/N	Tests	Test Methods
1	Soil Moisture	Oven Drying at 105°C
2	pH in Water: 1:2.5 Water Extract	Potentiometric - Water Extract
3	Electrical Conductivity (EC):1:2.5 Water Extract	Conductometric - Water Extract
4	Organic Matter (OM)	Modified ES ISO 14235:2015
5	Total Nitrogen (TN)	Modified ES ISO 11261:2015
6	Total (Cu, Zn, Cr, Cd, Pb, Ni)	Aqua-Regia digestion:- MP-AES
7	Total Potassium (K)	Aqua-Regia digestion:-FES

Remark:

1. This test report is only for specific sample(s) which has been tested by JIJE Analytical *Testing* Service Laboratory.
2. ND: Indicates not detected.

Verified by

Name	Signature	Date
Teshome Gezahagne		17/11/2021

Technical Signatory

Authorized by

Name	Signature	Date
Mulugeta Terefe		17/11/2021

Laboratory Manager

Tel : +251-37207 01/ 02
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Web site: www.jijelaboglassplc.com
Physical Address: Nifas Silk Lafto Sub City, Woreda 01, Lebu, Foziana Building 6th Floor, Infront of Varnero Real Estate, Addis Ababa, Ethiopia.

Annex IV: Pictures taken during site visit, consultation and sampling