Abstract: Due to various natural and anthropogenic activities, quality of water was deteriorated in most towns of the country. These changes make or forced the community to depend on unsafe and poor water consumption. River Gudar is one of the rivers found in towns of the country, and exposed to many anthropogenic activities done around the town. Importance of river Gudar is strongly linked to Domestic consumption, Irrigation, Industrial (HAEF) and other public health. Under the investigation physicochemical parameters and selected heavy metals for the quality of river Gudar for drinking purpose were characterized. The laboratory results for both physicochemical parameters and selected heavy metals were: Alkalinity (154 ± 15.556 mg/L), pH (8.44), Electrical Conductivity (316.47 ± 72.802 Scm\(^{-1}\)), TDS (149.37 ± 20.64 mg/L), Ammonia (41.00 ± 1.19 mg/L), Phosphate (3.50 ± 0.32mg/L), Total Hardness (156.87 ± 8.46 mg/L CaCO\(_3\)), Sodium (17.44 ± 2.87mg/L), Potassium (8.51 ± 0.33 mg/L) and some selected heavy metals such as Cu (0.29 ± 0.04 mg/L), Pb (2.5 ± 0.25 mg/L), Zn (0.63 ± 0.24 mg/L), Cd (0.79 ± 0.19 mg/L) and Ag (0.35 ± 0.17 mg/L) for water sample.

Key words: Flame Atomic Absorption Spectroscopy, Drinking water, physicochemical parameters.

1. Introduction

Throughout history, the quality of drinking water has been a factor in determining human welfare. It is clear that water pollution should be a concern of every citizen. Understanding the sources, interactions, and effects of water pollutant is essential for controlling pollutants in an environmentally safe and economically acceptable manner\[1\].

The quality of water, whether it is used for drinking, irrigation or recreational purposes, is significant for health in both developing and developed countries. In early days, water was primarily used for domestic needs like drinking, washing, bathing, cooking and etc. But due to industrial and urban development, requirement of water for these activities has increased along with domestic purpose. Quality of water can be described by its physical, chemical and microbial characteristics\[2\].

It is well known that water have played a crucial role in the growth and development of society. Urban growth, increased industrial activities, intensive farming and over use of fertilizers in agricultural productions are identified as major driving agents for degradation of water bodies. Urbanization growth coupled with industrialization during past few years has resulted into depleting water ecosystems of major cities in world wide. Water supply systems are important, but at the same time water waste treatment systems are equally important. According to S.D. Jadhav (2010), approximately 80% of water turns to waste water after its utilization. This wastewater should be properly treated before discharging into any water body. In case of river as a receiving body, when waste water is discharged on upstream side of river, downstream community uses the same water from the river for its day to day needs. Hence it is very much important that wastewater should be properly treated before discharging into river and maintaining sanctity of river. The sewage either seeps into the soils or pollutes ground water or it flows through streams and rivers and pollutes surface water \[2, 3\].

From these points of view, all water pollution is dangerous to the health of living organisms, but river pollution can be especially detrimental to the health of humans and animals because most of the people use Rivers as primary sources of potable water. The origination and spread of serious disease to humans and animals can result from river pollution. In some areas, the population has only one source of water, if this water is polluted; the population has no choice to use that water. Water pollution can arise from many sources. Individually the sources may be small, but their collective impact can be damaging. Water sources including rivers have increasingly become polluted with municipal sewage, industrial waste, industrial toxics, heavy metals, fertilizers, chemicals, radioactive substances, land sediment, and so on. For down streams, which lack proper water treatment and filtering facilities, public health is seriously threatened by polluted drinking water \[4\].

1.2. Heavy Metals in River water

Heavy /trace metals are among the most common environmental pollutants and their occurrence in waters and sediments indicate the presence of natural or anthropogenic sources. The accumulation of heavy metals in water bodies which accumulate in sediment can pose serious environmental problems to the surrounding areas. Heavy metal accumulation in
sediment could affect quality of water and the bio-
assimilation and bio-accumulation of metals in aquatic
organisms, resulting in potential long-term implications
on human health and ecosystem [5,6].

Heavy metal contamination has received much
attention with regard to accumulation in soils, uptake
by plants, and contamination of aquatic environments.
The disposal of heavy metals is a consequence of
several activities like chemical manufacturing, painting
and coating, mining, extractive metallurgy, nuclear and
other industrial wastes and products, burning of fossil
fuels, waste dumping and leaching of waste, production
and use of the compounds, dumps, urban run-off, sewage
effluents and agricultural run-off. Its cumulative poisoning effects are serious hematological
and brain damage, anemia and kidney malfunctioning.
Toxic metals to a large extent are dispersed in the
environment through industrial effluents, organic
wastes, refuse burning, and transport and power
generation. They can be carried to places many miles
away from the source depending upon whether they are
in the gaseous form or as particulates. Another means
of dispersal, especially in the hydrosphere is the
transport of the effluent from catchment areas that have
been contaminated by wastes from various industries.
Trace metals can be released to the different
environmental medium and finally enter to their
ultimate sink, lake sediments. Metals such as lead,
arsonic, cadmium, copper, zinc, nickel, and mercury are
continuously being added to our soils through various
agricultural activities such as agrochemicals usage and
long-term application of urban sewage sludge in
agricultural soils, industrial activities such as waste
disposal, waste incineration and vehicle exhausts, as
well as from anthropogenic sources [6,7].

1.2. Statement of the Problem
The main water pollution causes in the
Ethiopian context are, Industrial activities, Sewage,
domestic, municipals, rural wastewater, agricultural
activities. Since industries and socio-economic
activities are taking place in cities and major towns in
Ethiopia; the existence of water pollutants and effluents
from different sites become increasing from time to
time. This may cause pollution of rivers or any water
bodies around these activities. Regardless of parts of
the world they are living in and the social classes they
belong to, all human races in our planet need to have
clean water for a number of reasons, particularly
drinking purpose. Zewdie Abate (1984) pointed out that
as growing towns and the population increases from
time to time the water shortage and unsafe water
supply, which was the major problem of most towns of
Ethiopia, also increases. The increasing world
population with growing industrial demands has led to
a situation where protection of the environment has
become a major issue and a crucial factor for several
industrial processes, which will have to meet the
requirements of the sustainable development [8].

River Gudar is one among the rivers found in major
towns of Ethiopia which faces such huge pollution
problems. Along this river various socio-economic
activities are carried out by communities whom are
discharging their wastes to the river and the river
receives different effluents/pollutants from different
sources such as garages, domestic effluents (such as
shops, houses, hotels, schools), wastes from
municipality areas, effluents from market places such
as manure of the animals (cattle) and their urines, cafes
and restaurants from up-stream, Homicho Ammunition
Engineering Industry (HAEI) at downstream and many
other places. Due to this and other similar factors river
Gudar is facing/accepting such huge pollutants and
pollution problems that can harm communities who are
directly or indirectly dependent on this river for
drinking, irrigation purposes and other purposes like
agricultural purposes, and also can harm health
problems on animals and plants. Therefore, the study
was conducted in assessing the suitability of river
Gudar for drinking purpose based on the
physicochemical parameters and give recommendation
by comparing both the quantitatively and qualitatively
analyzed parameters with WHO and draft Ethiopian
drinking water quality standards. In addition to this, the
study was also conducted in determining the
concentration of heavy metals in this river.

1.3. Significances of the Study
The study on water has a great significance in
helping alleviate certain problems which can pose risk
to human health. The study was designed to conduct
determination of physicochemical parameters of river
Gudar for drinking purpose and determination of
selected heavy metals from the river. The work will
help to assess the pollution status of river Gudar and
suitability of this river for drinking purpose. Similarly,
the study is also important for providing scientific
evidences before someone using this river water
especially for every drinking purpose that help them to
take care from being infected by poisonous chemicals
and microorganisms from different sources.

1.4. Objectives
1.4.1. General Objective
The general objective of this research is to
assess the suitability of river Gudar for drinking
purpose using physicochemical quality parameters and
selected heavy metals.
1.4.2. Specific Objectives
➢ To investigate some physical and chemical water
quality parameters of river Gudar for drinking
purpose.
➢ To determine concentration of selected heavy
metals in the water sample of river Gudar
➢ To aware downstream or local community from the
adverse impact of use of this river water for
drinking purpose after laboratory analysis.

1.5. Scope of the Study
The scope of this study is to assess some
physicochemical water quality parameters such as pH,
conductivity, total alkalinity, TDS, TSS, total hardness, chloride, sulphate, nitrate, phosphate, calcium, magnesium, sodium, potassium, turbidity, ammonia, carbonate, bicarbonate and heavy metals such as Copper, Cadmium, Zinc, Lead and Silver of river Gudar. Accordingly:

- The study was conducted in dry time due to the factors such as floods which can affect the physical, chemical and biological behavior of the river water.
- The study was also delimited only to investigate physicochemical parameters of the river and determining the concentration of selected heavy metals of the river water.

2. Materials and Methods

2.1. Study Design

Gudar town is found in Oromia region of West Shoa zone, 10 km from Ambo town. A cross sectional survey on the quality of river Gudar for drinking purpose using different laboratory analysis was carried out. Similarly some heavy metal analysis of the river water was analyzed.

2.1. Sampling Procedures and Sample Collection

Purposive sampling method was employed. Purposely four sampling points were selected for analyzing its physicochemical parameters as well as some trace metal concentrations of the river. Water sample was collected from upstream site above Gudar town and labeled as GR1, around the municipality areas and labeled as GR2, at downstream site just before it has been mixed with the wastewater from the Homicho Ammunition Engineering Industry (HAEI) and labeled as GR3 and after it has been mixed with the wastewater from the industry and labeled as GR4.

The selection of these sampling points were based on or by taking into consideration the activities done around the river such as human interferences such as area where domestic wastes are discharged to the river i.e. from the town (municipal wastes), from market place (may be manure and urine of the animals in the market that is discharged into the river which is immediate pollutant of the river) and at downstream wastewater from Homicho Ammunition Engineering Industry (HAEI) and also agricultural activities at downstream.

Processes affecting water quality and their influence were taken into consideration when sampling sites and sampling/collecting time was selected, for example, such as floods which cause temporary variation of the river’s physical, chemical and other behavior. Water samples were collected three times from each sampling points selected by using polyethylene and glass bottles. Once the sample is collected from each sampling point, all physicochemical parameters selected were analyzed both in the laboratory and at the field of collection. Water samples from each of four sampling points were collected by direct immersion of bottles into the river and handled by rope. Before collection of water samples, bottles were washed with concentrated nitric acid and distilled water to avoid contamination.

2.1. Materials and Methods

Digital conductometer was used to measure Electrical Conductivity. pH of the river water sample was measured by pH meter (pH 600Milwaukee (Mauritius)) on the field. An ice bag was used for sample preservation. For trace metal analysis Atomic Flame Absorption Spectrometer (ELICO SL 194, INDIA) equipped with air/acetylene flame was used. Flame
Emission Spectrophotometer (ELICO CL 378 Flame Photometer, India) was used for the determination of potassium and sodium. Uv-vis Spectrophotometer (ELICO SL 160, INDIA) was used for the determination of Nitrate, Phosphate and Ammonia. Generally different sized volumetric flask, pipettes, measuring cylinders, burettes, drying ovens mechanical shakers desiccators and analytical measuring balances were used as per they were required.

Chemicals and reagents used during analysis periods are all analytical grade. 68% HNO₃ (INDIAN), 99% NaCl, 30% H₂O₂, 99% CaCO₃, 95% EDTA, 1000 ppm Cd (UNI-CHEM), 1000 ppm Cu (FLUKA), 1000 ppm Pb, 1000 ppm Ag were used and distilled, cleaning & dilution purpose.

Samples were used as per they were required. Generally different sized volumetric flask, pipettes, measuring cylinders, burettes, drying ovens mechanical shakers desiccators and analytical measuring balances were used for cleaning & dilution purpose.

Methods used in physicochemical analysis of Water Samples

pH of the water sample was measured by using pH meter (pH 600 Milwaukee (Mauritius); calibrated by buffer standards at pH 4, 7 and 10). Electrical conductivity (EC) of water sample was measured by digital conductometer. Total alkalinity, Calcium, Chloride, Magnesium, Total Hardness was determined by titration method. Turbidity of water samples was measured by digital Turbidimeter 2100A instrument. Total dissolved solids (TDS) were measured by Digital Conductometer. Ammonia (by stannous chloride method), nitrate, and phosphate (by phenate method) of the water sample were measured by Uv-vis spectrophotometer (ELICO SL 160, INDIA). Sulphate was determined by Gravimetric Method with Ignition of Residue. Potassium and sodium of water sample was measured by Flame Emission Spectrophotometer (ELICO CL 378 Flame Photometer, India.) flame photometric method. For heavy metals analysis Flame Atomic Absorption Spectrometer (ELICO SL 194, INDIA) was used.

3. Result and Discussion

3.1. Determination of Heavy Metal Concentration

Concentration of heavy metals (Cd, Pb, Cu, Zn, and Ag) was determined using Flame Atomic Absorption Spectrophotometer (SL194, DOUBLE BEAM AAS, ELICO). All instrumental measurements were performed using the respective hallow cathode lamps of target metals at recommended wavelengths and other operating conditions.

3.2. Method of Optimization Process

An appropriate digestion method was optimized for the analyses of heavy metals (Cd, Pb, Cu, Zn, and Ag) for water sample. During the optimization process, different digestion procedures that employ HNO₃, HClO₄ and H₂O₂ mixtures were selected from literature and assessed. The optimization procedure was selected on the basis of clarity of digestate, minimal acid volume consumption, digestion temperature and minimum time consumed. The optimum procedure chosen based on these criteria required a total of 3 hours for the complete digestion of 50 ml of water sample with 6 ml HNO₃, 4 ml HClO₄ and 2 ml H₂O₂. The digestion procedure gave a very clear solution which was suitable for the analysis of metals by FAAS.

Table 3.1: Optimization process for different volumes of acids, temperature and time

<table>
<thead>
<tr>
<th>Amount of sample used</th>
<th>Volume of acid consumed</th>
<th>Temperature of digestion</th>
<th>Time for complete digestion</th>
<th>Color Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 ml</td>
<td>10 ml HNO₃, 7 ml HClO₄, 2 ml H₂O₂</td>
<td>125 °C</td>
<td>3 hrs</td>
<td>Yellow color solution</td>
</tr>
<tr>
<td></td>
<td>6 ml HNO₃, 4 ml HClO₄, 2 ml H₂O₂</td>
<td>125 °C</td>
<td>3 hrs</td>
<td>Yellow color solution</td>
</tr>
<tr>
<td></td>
<td>4 ml HNO₃, 2 ml HClO₄, 2 ml H₂O₂</td>
<td>125 °C</td>
<td>3 hrs</td>
<td>Yellow color solution</td>
</tr>
<tr>
<td>50 ml</td>
<td>10 ml HNO₃, 7 ml HClO₄, 2 ml H₂O₂</td>
<td>140 °C</td>
<td>2 hrs</td>
<td>Light yellow color solution</td>
</tr>
<tr>
<td></td>
<td>6 ml HNO₃, 4 ml HClO₄, 2 ml H₂O₂</td>
<td>140 °C</td>
<td>2 hrs</td>
<td>Yellow color solution</td>
</tr>
<tr>
<td></td>
<td>4 ml HNO₃, 2 ml HClO₄, 2 ml H₂O₂</td>
<td>140 °C</td>
<td>2 hrs</td>
<td>Yellowish color solution</td>
</tr>
<tr>
<td></td>
<td>10ml HNO₃, 7ml HClO₄, 2ml H₂O₂</td>
<td>185 °C</td>
<td>3 hrs</td>
<td>Clear solution</td>
</tr>
<tr>
<td></td>
<td>6 ml HNO₃</td>
<td></td>
<td></td>
<td>Clear or white</td>
</tr>
</tbody>
</table>
50 ml 4 ml HClO₄
2 ml H₂O₂

<table>
<thead>
<tr>
<th>4 ml HNO₃</th>
<th>2 ml HClO₄</th>
<th>2 ml H₂O₂</th>
<th>185 °C</th>
<th>3 hrs</th>
<th>solution or colorless solution</th>
</tr>
</thead>
</table>

The average laboratory results of metals analyzed from all sampling points and from all replicate analysis were summarized in the following table:

**Table 3.2:** Average laboratory results of metals in water sample

<table>
<thead>
<tr>
<th>Metal</th>
<th>Mean ± SD (mg/L)</th>
<th>MDL (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>0.29 ± 0.0115</td>
<td>0.0433</td>
</tr>
<tr>
<td>Cd</td>
<td>0.79 ± 0.0470</td>
<td>0.0132</td>
</tr>
<tr>
<td>Pb</td>
<td>2.50 ± 0.0764</td>
<td>0.0183</td>
</tr>
<tr>
<td>Ag</td>
<td>0.35 ± 0.0351</td>
<td>0.0670</td>
</tr>
<tr>
<td>Zn</td>
<td>0.63 ± 0.0465</td>
<td>0.0281</td>
</tr>
</tbody>
</table>

**Table 3.3:** Average laboratory results for physicochemical parameters of water sample from all sampling sites

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>GR1</th>
<th>GR2</th>
<th>GR3</th>
<th>GR4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>8.50</td>
<td>8.45</td>
<td>8.34</td>
<td>8.46</td>
<td>8.44</td>
</tr>
<tr>
<td>2</td>
<td>Conductivity (Scm⁻¹)</td>
<td>249.40</td>
<td>373.65</td>
<td>257.85</td>
<td>385.00</td>
<td>316.47</td>
</tr>
<tr>
<td>3</td>
<td>TDS (ppm)</td>
<td>133.00</td>
<td>147.50</td>
<td>138.00</td>
<td>179.00</td>
<td>149.37</td>
</tr>
<tr>
<td>4</td>
<td>Alkalinity (ppm)</td>
<td>164.00</td>
<td>137.00</td>
<td>145.00</td>
<td>170.00</td>
<td>154.00</td>
</tr>
<tr>
<td>5</td>
<td>Potassium (mg/L)</td>
<td>8.75</td>
<td>8.80</td>
<td>8.10</td>
<td>8.40</td>
<td>8.51</td>
</tr>
<tr>
<td>6</td>
<td>Ammonia (mg/L)</td>
<td>2.62</td>
<td>2.15</td>
<td>4.51</td>
<td>4.35</td>
<td>3.41</td>
</tr>
<tr>
<td>7</td>
<td>Sodium (mg/L)</td>
<td>15.31</td>
<td>16.80</td>
<td>16.00</td>
<td>21.65</td>
<td>17.44</td>
</tr>
<tr>
<td>8</td>
<td>Nitrate (mg/L)</td>
<td>5.23</td>
<td>6.44</td>
<td>6.85</td>
<td>7.55</td>
<td>6.51</td>
</tr>
<tr>
<td>9</td>
<td>Sulphate (mg/L)</td>
<td>35.03</td>
<td>96.71</td>
<td>53.74</td>
<td>97.05</td>
<td>70.63</td>
</tr>
<tr>
<td>10</td>
<td>TSS (ppm)</td>
<td>125.40</td>
<td>121.80</td>
<td>130.00</td>
<td>123.00</td>
<td>125.05</td>
</tr>
<tr>
<td>11</td>
<td>Phosphate (mg/L)</td>
<td>3.21</td>
<td>3.25</td>
<td>3.85</td>
<td>3.67</td>
<td>3.49</td>
</tr>
<tr>
<td>12</td>
<td>Chloride (mg/L)</td>
<td>4.95</td>
<td>3.92</td>
<td>3.50</td>
<td>5.32</td>
<td>4.37</td>
</tr>
<tr>
<td>13</td>
<td>Turbidity (NTU)</td>
<td>2.42</td>
<td>4.25</td>
<td>1.23</td>
<td>3.45</td>
<td>2.83</td>
</tr>
<tr>
<td>14</td>
<td>Total hardness (mg/L CaCO₃)</td>
<td>152.01</td>
<td>157.52</td>
<td>149.35</td>
<td>168.45</td>
<td>156.83</td>
</tr>
<tr>
<td>15</td>
<td>Calcium (ppm)</td>
<td>70.84</td>
<td>75.12</td>
<td>62.96</td>
<td>65.82</td>
<td>68.68</td>
</tr>
<tr>
<td>16</td>
<td>Magnesium (ppm)</td>
<td>18.46</td>
<td>21.14</td>
<td>20.89</td>
<td>24.89</td>
<td>21.34</td>
</tr>
<tr>
<td>17</td>
<td>Carbonate (ppm)</td>
<td>4.70</td>
<td>3.21</td>
<td>2.65</td>
<td>4.12</td>
<td>3.67</td>
</tr>
<tr>
<td>18</td>
<td>Bicarbonate (ppm)</td>
<td>138.74</td>
<td>123.24</td>
<td>117.66</td>
<td>132.78</td>
<td>128.10</td>
</tr>
</tbody>
</table>

**Figure 3.1:** Average laboratory results for physicochemical parameters of water sample from all sampling sites
3. Conclusion and Recommendations

- The increasing values of some physicochemical water quality parameters indicates that the river water located near the site of collection is not safe for drinking purpose but it can be used for agricultural activities such as irrigation purpose. The quality of river Gudar is getting contaminated especially by heavy/trace metals with growth of the town due to investment activities.
- The community and concerned body should take the controlling mechanism such as treating wastewater discharged from HAEF into the river and controlling municipal wastes discharged from the town into water body.
- The study was conducted within period of three months. It may lack comprehensiveness. Further studies should be conducted in different seasons considering other water quality parameters such as biological water quality parameters and other water quality parameters for drinking and irrigation purpose.
- The study will be taken as the starting material for the interested body/group for further analysis of physicochemical quality parameters and other parameters by sophisticated equipments and standardized laboratory.

Reference
2. WHO (2001), Guidelines, Standards and Health: Assessment of risk and risk management for water-related infectious disease, Geneva