ESTIMATION OF HEAVY METALS IN DRINKING WATER OF TARAHARA, ITAHARI SUB-METROPOLITIAN, NEPAL

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Estimation of heavy metals in drinking water of Tarahara, Itahari sub-metropolitian, Nepal

A project work submitted

To

Department of Chemistry

Central Campus of Technology

For the fulfillment of project work of fourth year of Bachelor's Degree of Science (B.Sc.)

By:

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Central Campus of Technology

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Board of examiners and certificate of approval

This project work entitled "Estimation of heavy metal in drinking water of Tarahara, Itahari sub-metropolitian, Nepal", by Ashish Bhattarai (Roll No.:500080001), T.U Regd. No.: (5-2-008-0094-2015), under the supervision of Mr. Debendra Rai, Central Campus of Technology, Hattisar, Dharan, Department of Chemistry, Nepal, is hereby submitted for the partial fulfillment of Bachelor of Science (B.Sc.) Degree in Chemistry. This project work had not been submitted in any other university or institution previously and has been approved for the award of Bachelors of Degree.

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This is recommended that **Ashish Bhattarai** (Roll No.:500080001 ; Tribhuvan University Registration Number: 5-2-008-0094-2015) has carried out project work entitled " Estimation of heavy metal in drinking water of Tarahara, Itahari sub-metropolitian, Nepal" as a partial fulfillment of 4 years Bachelor degree of 4th year in chemistry under my supervision. To my knowledge, this work has not been submitted for any other degree.

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Declaration

I hereby declare that the project work entitled "Estimation of heavy metal in drinking water of Tarahara, Itahari sub-metropolitian, Nepal" which is being submitted to the Department of Chemistry, Central Campus of Technology, Dharan, Tribhuvan University, Nepal for the partial fulfillment of degree of Bachelor of Science in Chemistry is my original work carried out by me under the supervision of Mr. Debendra Rai , Department of Chemistry, Central Campus of Technology, Dharan, Tribhuvan University.

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Abstract

Heavy metals in drinking water pose a threat to human health. Populations are exposed to heavy metals primarily through water consumption and few heavy metals can bio accumulate in human body and may induce cancer and other risks. Quantitive determination of five heavy metals (iron, manganese, Nickel, Lead and Cadmium) in five water samples collected from Tarahara, Itharai sub-metropolitan city was carried out by using atomic absorption spectrophotometry by standard method (APHA-3111 B, 1998). Physical parameters (pH, Conductivity, Temperature and TSS) were also measured in the tested samples. The analysis showed that the concentration of Iron and Manganese were found higher whereas Nickel, Lead and Cadmium were found within the standard limits given by NDWQS in tested samples of water. All the values of physical parameters were within the range specified by WHO guidelines of drinking water.

Key words: Heavy metals, pH, conductivity, Temperature, TSS, Atomic Absorption Spectrophotometry.

Table of Contents

List of Tables

List of figures

List of Abbreviations

Abbrevations	Full form
AAS	Atomic absorption spectroscopy
ASTDR	Agency for Toxic Substances and Disease Registry
UNICEF	United Nations International Children's Emergency Fund
FAAS	Flame atomic Absorption spectroscopy

1. INTRODUCTION

1.1 General introduction

1.1.1 Area introduction:

Tarahara is a town in eastern region of Nepal located in Itaharai sub-metropolitan city, Sunsari District province no-1. It is situated in between Dharan and Itahari. The climate of Tarahara is warm and temperate. Much more rainfall occur in summer as compared to winter. Tarahara is also a fast growing town in eastern Nepal which is also famous for agriculture. There is also government owned agricultural research center which is mostly famous for pisciculture. The ground water resource of Tarahara mostly depends on tube wells, rivers and wells.

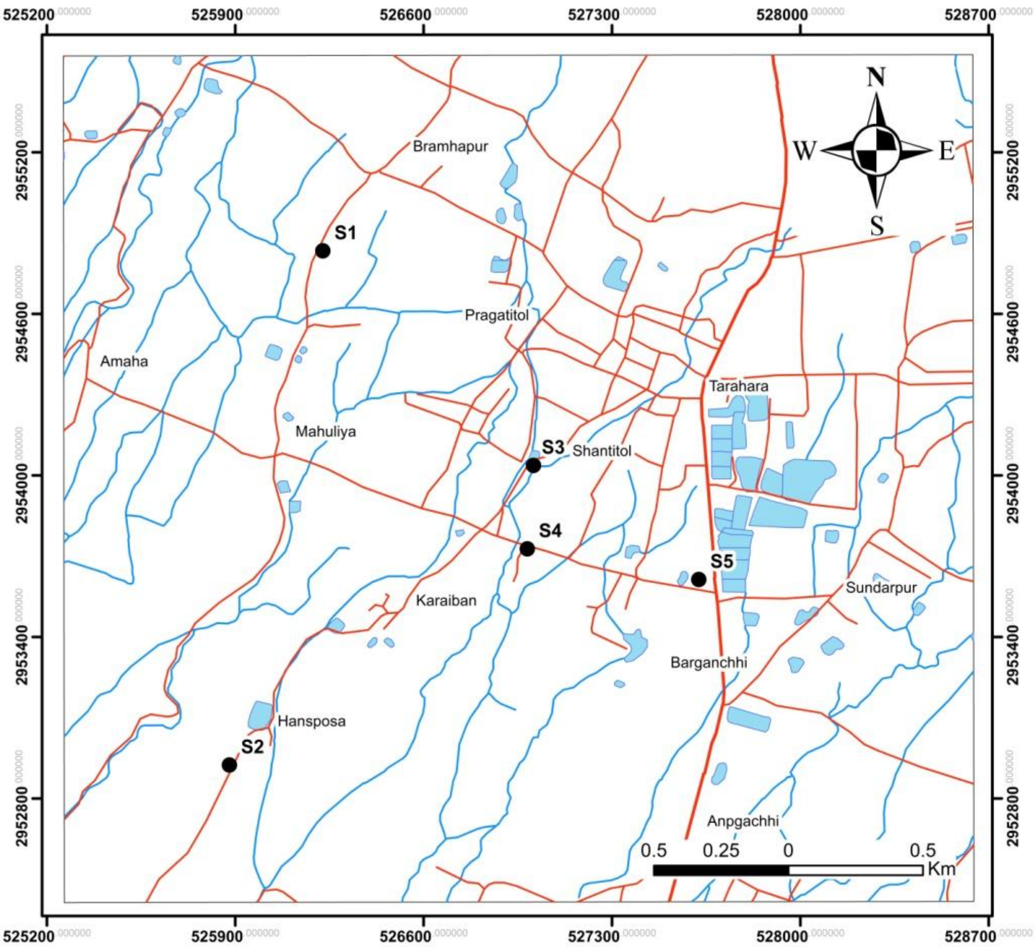

Fig 1 Location Map (Gis Software)

S1, S2, S3, S4 and S5 were the places from where the samples were collected.

Table 1: Locations of Samples collection.

Sample code	Location (Name)
S1	Jabdi Chowk
S2	Pokhari dil
S3	School line
S4	Laliguras Chowk
S5	Homes Area

1.1.2 Water and Heavy metals:-

Water covers about 71% of the earth surface but available fresh drinking water is only 3% out of which 69% is trapped as ice in two Polar Regions. The remaining fresh water exist in rivers, lakes and surface aquifers which human beings, plants and other animal species can use. This distribution must be carefully managed to avoid irreversible depletion of the resource (Yeazadani, 2016).

Water is considered polluted if some substance or condition is present to such degree that the water cannot be used for a specific purpose. Olaniran defined water pollution to be the presence of excessive amounts of a hazardous substance in water in such a way that it can be no useful. Pollution is the introduction of a contamination into the environment. It is created by industrial and commercial wasters, agricultural practices, everyday human activities and various means of transportation. The water we drink must be pure, free from pollution and supply of safe drinking water to human is one of the major prerequisites for a healthy life. Polluted water causes various serious problems on health (Owa, 2014). Like many developing countries, Nepal faces a problem in drinking water quality and availability. Throughout Nepal people are exposed to several healths releted complication resulting from water pollution (Pandey and shakya, 2009). Increased urbanization and industrialization are to be blamed for an increased level of trace metals, especially heavy metals in our water (Chaitali and Dhote, 2013).

Water pollution by heavy metal has become a serious problem in the world. Heavy metals are defined as those metals and metalloids that have high density and toxic to even at low concentration (chaitali and Dhote, 2013). Heavy metals have relatively high density compared to water (jaishankar et al., 2014). There are over fifty elements that can be classified as heavy metals seventeen of which are considered to be very toxic and relatively available (chaithali and Dhote, 2013).

1.1.3 Source of heavy metals:

Heavy metals enter the environment from natural and anthropogenic sources. The most significant natural sources are weathering of minerals, erosion and volcanic activity while anthropogenic sources include mining, smelting, electroplating, use of pesticides and (phosphate) fertilizers as well

Table 2: Source of heavy metals

Heavy metals	Source
As	Pesticides and wood preservatives
Cd	Paints and pigments, plastic stabilizers, electroplating, incineration of cadmium-containing Plastics and phosphate fertilizers
Cr	Tanneries, steel industriesand fly ash
Cu	Pesticides and fertilizers
Hg	Release from Au–Ag mining and coal combustion andmedical waste
Ni	Industrial effluents, kitchen appliances, surgical instruments, steel alloys, automobile and Batteries
Pb	Aerial emission from combustion of leaded petrol, battery manufacture, herbicides and Insecticides
Mn	Widely distributed throughout the earth’s crust
Fe	Drinking water pipes.

(Ali et al., 2013 and Nutritional and Environmental Medicine London, 2013)

1.1.4. Importance and effect of heavy metals:

Regarding the role of heavy metals in drinking water heavy metals are classified as essential and non-essential. Essential heavy metals are those which are needed by living organism in minute quantity for vital physiological and biochemical functions. Examples of essential heavy metals are Fe, Mn, Cu, Zn and Ni and Non-essential heavy metals are those which are not needed by the living organism for any physiological function (Ali et al., 2013). Toxicity level depends on type of metals, its biological role and the type of organism exposed to it. Heavy metals also effect on aquatic flora and fauna which through biomagnifications enters food chain and ultimately affect the human being as well (chaithali and Dhote, 2013). Increases in concentration of heavy metals in human body have adverse health effect because they interfere with the normal functioning of living system (Ali et al., 2013). Some of the non essential heavy metals even they do not have biological role but remain present in other form harmful for the human body. Some of them act as pseudo element in the body while at certain time they may interfere with metabolic processes (jaishankar et al., 2014).

1.2 Statement of Problem

Over dose of iron in the body result genetic disorders (WHO, 2003). Lead has a carcinogenic property and it affects both the respiratory and digestive system and it suppress the immune system as well.Lead is particularly harmful in children, affect their nervous system (zong et. al, 2005)..Excess of manganese in the body effect the brain (Nutritional and Environmental Medicine London, 2013). Eating food or drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea, and sometimes death (Agency for toxic substance and disease Registry, 2012).
In india,.Ramchandra and his team estimated heavy metals in various areas of hyderabad and found that concentration of Pb, Cd and Cr were greater than the limit value where as in context of Nepal Aryal and his team performed a research to find out the quality of drinking water in Myagdi district. He found that arsenic concentration were higher than the limit value. Although heavy metal estimation had been done in various countries and also at various places of Nepal but such researches has not been done in itahari, Sunsari.Therefore, it is highly obligatory that heavy metasl in drinking water of sunsari district be estimeted.

1.3 Research Objectives

1.3.1 General Objective

To identify the presence of heavy metals in drinking water of Tarahara.

1.3.2 Specific objective

To study the physicochemical parameter of drinking water of Tarahara.
To estimate the amount of Fe, Mn, Ni, Pb and Cd in drinking water of Tarahara.
To compare the amount of Fe, Mn, Ni, Pb and Cd in drinking water of Tarahara.

1.5 Limitation:

Although there are over 50 different heavy metals that may be present in water, this study will estimate the amount of only five of them (Fe, Mn, Ni, Pb and Cd). The sample size taken in this study is very small because of time and budgetary constraints.

2. LITERATURE REVIEW

2.1 Drinking Water

Safe and readily available water is important for public health whether it is used for drinking, domestic use and food production or recreational purposes. Improved water supply, sanitation, and better management of water resources can boost countries economic growth and can contribute greatly to poverty reduction. In 2010, the UN General Assembly explicitly recognized the human right to water and sanitation. Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible and affordable water for personal and domestic use. By 2025 half of the world's population will be living in water stressed area (WHO, 2019)

2.2 Heavy metal and their source.

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least five times greater than that of water. Their multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment raising concerns over their potential effects on human health and the environment. Their toxicity depends on several factors including the dose, route of exposure and chemical species as well as the age, gender, genetics and nutritional status of exposed individuals (Tchounwou et al., 2012). There are about 40 elements that fall into this category. Heavy metals are largely found in disperse form in rock formations. These heavy metals are distributed in the environment through several natural processes such as volcanic eruptions, spring waters, erosion, bacterial activity and anthropogenic activities which include fossil fuel combustion, industrial processes, agricultural activities as well as feeding (Ali et al., 2013). Generally the heavy metal enter into the water supply by industrial and consumer material or even from the acid rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater. Not only this but also heavy metal enter into the drinking water source through Pb pipes (Pandey and Madhuri, 2014)

2.3 Heavy metal in plant

Many heavy metals are considered to be essential for plant growth. Some of these heavy metals like Cu and Zn serve either as cofactor and activators of enzyme reactions these essential trace metal nutrients take part in redox reactions, electron transfer and structural functions in nucleic acid metabolism. Heavy metals are considerably dangerous for the aquatic environment. This can be due to their toxicity, wide sources, lack of biodegradable properties and accumulative behavior (Nowrouzi et al., 2012). Heavy metal ions such as Cu^{+2}, Zn^{+2}, Mn^{+2}, Fe^{+2}, Ni^{+2} and Co^{+2} are essential micronutrients for plant metabolism but when present in excess act as non-essential. Metals such as Cd^{+2}, Hg^{+2}, Ag and Pb^{+2} can become extremely toxic (Das et al., 2011). Bryophytes have been frequently used as monitors of heavy metal pollution in the field of studies but their concentration also effect in the growth (Sidhu and Brown, 1996)

2.4 Heavy metal in aquatic animals

Pollution of different environments is due to human activities in recent years. One of such pollution is marine pollution by heavy metals. The heavy metals are accumulated in the marine environment then transfer to the marine organisms. When their concentrations exceed in the body they become toxic and cause several health problems. The fishes became sick then die (Das et al., 2011). Heavy metal enters in the body of fish by three different potential ways by gills, body surface and by digestive tract. Humans are also affected by intake of effected fishes for mostly people of those areas where main food is fish (Afshan et al., 2014)

2.5 Heavy metal in animal and human body

Chemical elements in both Free State and a variety of chemical compounds are included in all cells and tissues of the human body. For each element there is optimum range of concentration to perform various functions. On the contrary at permissible limit metals are important for enzymatic activity and genetic material integrity in biological system. Some of the heavy metal are used for cellular division and contributes in carbohydrate, lipid and nucleic acid metabolism (oves et al., 2016).Excess of heavy metals than the permissible limit bioaccumulate in living organisms and the human body through various processes causing adverse effects. In the human body these heavy metals are transported and compartmentalized into body cells and tissues binding to proteins, nucleic acids destroying these macromolecules and disrupting their cellular functions. Heavy metal toxicity can have several consequences in the human body. It can affect the central nervous function leading to mental disorder, damage the blood constituents, may damage lungs, liver, kidneys and other vital organs promoting several disease conditions. Also the long term accumulation of heavy metals in the body may result in slowing the progression of physical, muscular and neurological degenerative processes that mimic certain diseases such as Parkinson’s disease and Alzheimer’s disease (Engwa et al., 2019). Repeated long-term contact with some heavy metals or their compounds may even damage nucleic acids cause mutation and mimic hormones there by disrupting the endocrine and reproductive system and eventually lead to cancer (lars jarup, 2019) The concentrations of heavy metals in the environment have increased significantly in recent decades. The sources of heavy metals in food crops vary in the developing and developed world. The deposition of metal on food crops and the use of industrial effluents and sewage sludge as fertilizers are the primary contamination sources in soil–crop systems in developed countries. The inhalation of soil and dietary intake of fruits, crops and vegetables contaminated with metals or metalloids can lead to gastrointestinal cancer (Rai et al., 2019). The infants and younger population are more prone to the toxic effects of heavy metals as the rapidly developing body systems in the fetus, infants and young children are far more sensitive Childhood exposure to some metals can result in learning difficulties, memory impairment, damage to the nervous system and behavioral problems such as aggressiveness and hyperactivity. At higher doses heavy metals can cause irreversible brain damage. Children may receive higher doses of metals from food than adults since they consume more food for their body weight than adults (khan tareen et al., 2013).

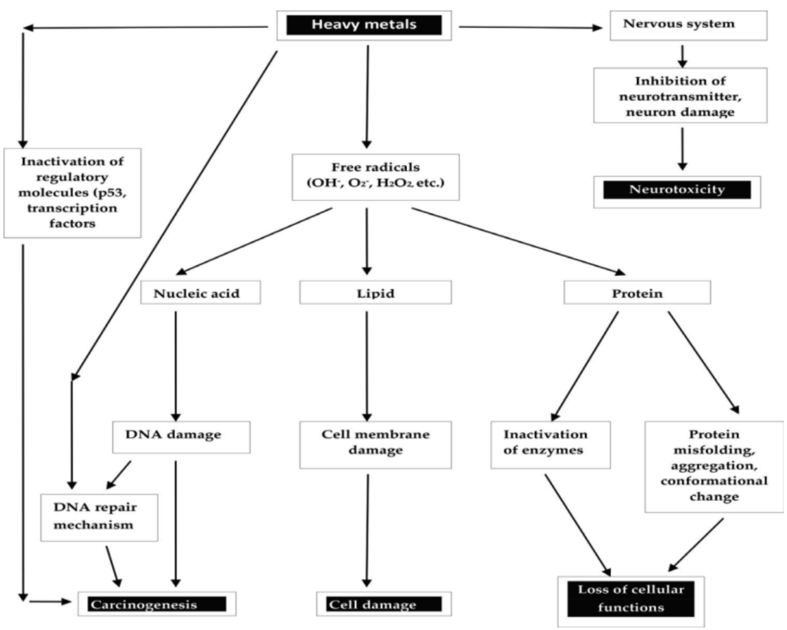

Fig 2 Pathway of heavy metal source and exposure to human (Engwa et al., 2019).

2.6.1 Iron:

Iron is the second most abundant metal in the earth's crust of which it accounts for about 5%. Melting point of iron is found to be 1535 ºC where as the specific gravity is found to be 7.86 at 25º C (WHO, 2003).From the ancient time man has recognized the special role of iron in health and disease. Until 1932 iron was not important. The importance of iron was finally settled by convincing proof that inorganic iron was needed for hemoglobin synthesis. Iron is biologically essential component of all living organism. The body requires iron for the synthesis of oxygen transport proteins (Abbaspour et al., 2014). Iron is a part of hemoglobin, myoglobin, cytochrome, aconitase, fumarate reductase and many proteins and enzymes essential for metabolic (Nagajoti et al., 2010). Iron intake is very important especially for people over 50 years old. For aging diseases such as Alzheimer's disease, atherosclerosis and others iron excess has a major contribution. Iron is introduced through food and water therefore it is necessary to know its concentrations (Pavlosvka et al., 2015). Humans have no way to excrete iron and loose only 2mg per day from epithelial surfaces (American society of hematology, 2018). This loss is balanced by intestinal absorption. Iron demand occurs during infancy and childhood due to growth and development demands (Sophie et al., 2014)

Excess of iron intake form the drinking water and many other sources is becoming a serious problem in the world. Iron poisoning has always been topic of interest mainly to pediatricians. Children are highly susceptible to iron toxicity as they are exposed to a maximum of iron containing products. Excess iron uptake is a serious problem in developed and meat eating countries and it increases the risk of cancer ((Jaishankar et al., 2014). Excess of iron then the limit value can also cause number of chronic disease like cancer, diabetes, cardiovascular disease and many neurodegenerative conditions are also associated with excess of iron (Marianne, 2017). Toxic effects of iron also include depression, coma and convulsion (who, 2003).

2.6.2 Manganese

Manganese is one of the most abundant metals in Earth's crust usually occurring with Iron. Manganese occurs naturally in the environment and constitutes 0.1% of the Earth's crust (Guidelines for Canadian drinking water quality, 2019). Manganese can exist in 11 oxidative states. The most environmentally and biologically important manganese compounds are those that contain Mn^{2+}, Mn^{4+} or Mn^{7+} (WHO, 2011).

Manganese dioxide and other manganese compounds are used in products such as batteries, glass and fireworks. Manganese compounds are used in fertilizers, varnish, fungicides and as livestock feeding supplements (WHO, 2011). Manganese within the range of limit value in drinking water is good for health. Manganese is found in both ground and surface water. Our body needs some amount of manganese to become healthy but excess can be harmful to health. The recommended daily intake of manganese depends on person's age and sex (Minnesota department of health, 2018).

Although manganese is an essential nutrient at low doses chronic exposure to high doses may be harmful. Human activities are also responsible for much of the manganese contamination in water. Manganese deficiency in humans appears to be rare because manganese is present in many common foods. The health effects from over-exposure of manganese are dependent on the route of exposure, the chemical form and the age at exposure. Excess of manganese than the limit value can cause tremor and mental disturbance (united state Environmental protection agency, 2004). A number of studies in animal models have demonstrated the CNS to be the most susceptible target of toxicity resulting from oral exposure to manganese followed by reproductive systems. Manganese has been shown to have effects on the respiratory tract following oral exposure (Guidelines for Canadian drinking water quality, 2019).

2.6.3 Nickel:

Nickel is a lustrous white, hard and ferromagnetic metal. The primary source of nickel in drinking-water is leaching from metals in contact with drinking-water such as pipes and fittings. However nickel may also be present in some groundwater as a consequence of dissolution from nickel ore-bearing rocks (WHO, 2005). Pure nickel is a hard, silvery-white metal which has properties that make it very desirable for combining with other metals to form mixtures called alloys (ASTDR, 2005)

Human exposure to nickel occurs primarily via inhalation, ingestion and dermal Absorption. Nickel plays a fundamental role in living organisms revealing it’s double faced nature of both as an essential and toxic element Nickel is a necessary component in the active site of several essential metallo-enzymes in bacteria and lower eukaryotes. In higher eukaryotes the only known nickel-depending enzyme is plant urease (Zambelli and Ciurli, 2013).

Exposure to nickel compounds yields a variety of adverse effects on humans. Carcinogenesis and allergy are the major health hazardous health effect caused by the nickel exposure. Chronic nickel exposure can produce serious respiratory, cardiovascular and kidney diseases. Some alterations in immune response in animal models have been observed as a result of nickel contact. High exposure to nickel impairs the normal homeostasis of essential metal ions decreasing the levels of calcium, magnesium, manganese and zinc in different tissues. (Zambelli and Ciurli, 2013). 2.5-year-old girl died after ingesting about 15 g of nickel sulfate crystals. Cardiac arrest occurred after 4 h. Nickel salts affect the T-cell system and suppress the activity of natural killer cells in rats and mice (WHO, 2005).

2.6.4 Lead

Lead is the commonest of the heavy elements accounting for 13 mg/kg of Earth's crust. From a drinking-water perspective the almost universal use of lead compounds in plumbing fittings and as solder in water distribution systems is important. Lead pipes may be used in older distribution systems and plumbing (WHO, 2011).

One of the major uses of lead is that lead is that it use for the manufacturing of battery. It reports that US industry uses 1.3 million tons of lead annually. Tetraethyl and Tetramethyl lead are important because of their extensive use as antiknockimg compounds in petrol but their use for this purpose has been almost completely phased out in North America and Western Europe although not in Eastern Europe or many developing countries (WHO, 2011).

Lead is a highly toxic metal whose widespread use has caused extensive environmental contamination and health problems in many parts of the world. Lead is an extremely toxic heavy metal that disturbs various plant physiological processes Toxicity of lead is also called lead poisoning can be either acute or chronic Lead poisoning can also occur from drinking water. The pipes that carry the water may be made of lead and its compounds which can contaminate the water (Jaishankar et al., 2014). Lead exposure is consistently associated with intellectual and other neurological defect. Over exposure of lead in children cause neurological disorder. IHME estimated that in 2016 lead exposure accounted for 540000 deaths. Lead is cumulative toxicants that affect multiple body system. Lead in the body is distributed to the brain, liver, kidney and bones (WHO, 2018). Lead is a particularly dangerous chemical as it can accumulate in individual organisms and also in entire food chains. Gonad dysfunction in men including depressed sperm counts has been associated with blood lead levels of 40–50 μg/dl (*90–93*). Reproductive dysfunction may also occur in females occupationally exposed to lead. Lead poisoning also cause carcinogenicity (WHO,2011)

2.6.5 Cadmium:

Cadmium is a metal found in the earth crust associated with Zinc, lead and copper ores. Pure cadmium is soft and silver-white metal. Cadmium is generally in +2 oxidation state. It is soluble in dilute nitric acid and concentrated sulfuric acid (WHO, 2011). Cadmium can enter into the drinking water by the penetration of industrial wastewater containing cadmium into the water distribution network and also penetration via polyethylene tubes and containers (Fakhri et al., 2014).

Cadmium metal is used mainly as an anticorrosive electroplated onto steel. Cadmium sulfide and selenide are commonly used as pigments in plastics. Cadmium compounds are used in electric batteries, electronic components and nuclear reactors (WHO, 2011).

Human health effects related to cadmium (Cd) exposure in the general environment were first reported from western Japan after the Second World War. Dr Hagino, a local practitioner in Toyama prefecture diagnosed many women exhibiting a bone disease with many pathological fractures (Nordberg and china, 2003). The presence of cadmium in drinking water can be dangerous for human health because of toxicity and biological accumulation. The consumption of water which contains Cd in high concentration can lead to Bone and Kidney disease. The international Agency for Research on cancer has classified cadmium as a group “A” carcinogen. Chronic exposure on cadmium cause kidney failure and itai - itai disease (Fakhri et al., 2014). Cadmium is the 7th most toxic heavy metal as per ASTDR ranking. It is one of the toxic metals to human being because once it gets absorbed by the humans gets accumulate in the human body throughout the life. In the US more than 500,000 workers get exposed to toxic cadmium each year as per The Agency for Toxic Substances and Disease Registry (Jaishankar et al., 2014).

2.7 Method of removing heavy metals in drinking water:

Removal of heavy metal is an important step toward safe drinking water. Shakhawat chowdhury and his team study on removal of heavy metal in drinking water practice in developing countries and also find out success and failures of such method. According to them several of methods have reported to remove heavy metals from wastewater and drinking water. Adsorption was found to be the method of choice with various adsorbents being available. The other methods include chemical precipitation, physical separation, ion exchange, membrane filtration, membrane filtration, membrane distillation and hybrid method. Some of these methods are expensive and likely to impractical for application in low and medium income countries.

Table 3 Method of removing heavy metal from drinking water.

Heavy metal	Coagulation	Ion exchange	Precipitation softening	Activated alumina	Reverse Osmosis Membranes	Activated carbon	Low-cost activated carbon	Alginate beads
Arsenic	++	+++	++	+++	+++			
Cadmium	+++	+++	+++		+++			
Mercury	+++		+++		+++	+++		
Selenium	++	+++		+++	+++			
Uranium	++	+++	++	+++				
Lead	+++		+++			+++	+++	+++

++: ≥50% removal success; +++: ≥80% removal success (Chowdhury et al., 2016)

2.8 pH in drinking water:

The technical definition of pH is that it is the measure of the activity of the hydrogen ion (H^+) and is reported as the reciprocal of the logarithm of hydrogen ion activity. According to WHO maximum concentration of pH in drinking water range from 6.5 to 8.5 The pH of water is a measure of the acid-base equilirium and in most natural waters is controlled by carbon dioxide-bicarbonate-carbonate equilibrium system. An increased carbon dioxide concentration will therefore lower pH whereas a decrease will cause it to rise. pH is major importance in determining the corrosivity of water. In general lower the pH, higher the level of corrosion (WHO, 2003). Low pH water are gives sour taste of drinking water and cause blue green staining of sinks and other household fixtures so pH indirectly affect our health (culligan, 2019).**E**xposure to extreme pH value result in irritation to the eyes ,skin and mucous membrane. Eye irritation and exacerbation of skin disorders have been associated with pH values greater than 11. In addition solutions of pH 10–12.5 have been reported to cause hair fibers to swell. In sensitive individuals gastrointestinal irritation may also occur. Exposure to low pH values can also result in similar effects (WHO, 2003).

2.9 Conductivity in drinking water:

The ability of a solution to conduct an electrical current is governed by the migration of ions and is dependent on the nature and numbers of the ionic species in that solution (Reda, 2016). According to WHO, Maximum limit value of Electrical conductivity is 400µs/cm. The electrical conductivity of water increase by 2-3% for an increase of 1ºC of water temperature (Smart fertilizer management, 2018). Pure water is not a good conductor of electric current rather's good insulator. Generally, the amount of dissolved solid in water determines the electrical conductivity of water (Meride and Ayenew, 2016). Electrical conductivity of water is a direct function of its total dissolved solids. Hence it is an index to represent the total concentration of soluble salts in water. (C. R. Ramakrishna et al., 2008).

2.10 Total suspended solid:

A total suspended solid (TSS) is defined as solids in water that can be trapped by a Filter (Reda, 2016). According to WHO maximum limit value of TSS in drinking water is <30 mg/L greater than this value is not accepted. TSS is particle that is larger than 2 microns found in the water column. Anything smaller than this is called dissolved solid (Rshydro, 2019). Most suspended solids are made up of inorganic materials though bacteria and algae can also contribute to the total solids concentration. The more suspended solid present in water less clear the water will be (Fondriest environmental, 2019).

2.11 Temperature:

High temperature negatively impact water quality by enhancing the growth of micro-organisms which may increase the taste, odour, colour and corrosion problem (UNICEF, 2009). Therefore, it is important that groundwater temperature is not too high in order to check microbial proliferation. Temperature affects biological, chemical and physical activities in Water. Not only this, increase in temperature of water also decrease solubility of gases such as O_2, CO_2, N_2 and CH_4 (oyem et al., 2104).

2.12 National Drinking Water Quality Standard (NDWQS):

Concentration of Arsenic in drinking water should not exceed 0.05 mg/L. likewise concentration of Lead, Mercury, should not exceed 0.01 mg/L, 0.001 mg/L respectively. The following table 4 shows upper concentration limits of various heavy metals as described by NDWQS.

Table 4 National Drinking Water Quality Standard

S.N	Chemical	Upper concentration Limits (mg/l)
1	Arsenic	0.05
2	Lead	0.01
3	Mercury	0.001
4	Iron	0.3
5	Copper	1
6	Cadmium	0.003
7	Zinc	3
8	Nickel	-
9	Manganese	0.2

(Government of Nepal, Ministry of Physical Planning and Works, 2005)

3. METHODOLOGY

3.1 Laboratory Setup:

The whole project was done in the laboratory of Nepal Batabaran Sewa Kendra, Biratnagar and chemistry laboratory of Central Campus of Technology, Hattisar, Dharan.

3.2 Experimental Materials

3.2.1 Chemicals

3.2.1.1 Standard solution

1000 ppm standard solution of iron, manganese, nickel, lead and cadmium was obtained from Mumbai India.

3.2.1.2 Water

Triple distilled water was used.

3.2.1.3 Instrument

- AAS

  Model iCE 3000 AA. , single atomizer AAS with fully automatic gas box.
- A digital balance
- Conductometer

  Conductivity meter model 1601 with the range of 0-200µs/cm and resolution of 0.01 µs/cm.
- PH meter

  pH meter model LT-10 with the range of 0.00 – 14.00 and resolution of ± 0.05.

3.3 Methodology

3.3.1 Sample collection:

Five samples from different tube wells of five different locations of Tarahara were obtained. To avoid possible contamination, the empty polythene bottles were used for the collection of water sample and were labeled accurately. These samples were collected in 500ml capacity bottle and stored in refrigerator at 4ºC until further used.

3.3.2 Determination of pH: (Reda, 2014)

The pH of each sample was measured with portable field pH meter model LT-10 pre calibrated at buffer of pH 4 and 7.

3.3.3 Determination of TSS: (Reda, 2014)

For Total suspended solid (TSS), 100 ml of water sample was filtered through a preweighed filter paper. The filtered papers were dried at 103-105 ºC in oven and TSS was determined by the following formula.

$$TSS\ (mg) = \frac{W_2 - W_1}{\text{Volume of sample (ml)}}$$

Here W_2=post weight of the filter paper

W_1= pre weight of the filter paper

3.3.4 Temperature measurement: (Oyem et al., 2014).

Temperature was measured immediately after the sample was collected and was measured by using glass thermometer

3.3.5 Determination of Electrical Conductivity (EC): (Reda, 2014).

EC was measured by using conductivity meter model 4200. Before measuring the probes were rinsed with distill water and conductivity of distill water was checked. Then the probe was immersed in a beaker containing water sample and moved up and down taped on the beaker to make the electrodes free from any bubbles. Then data was recorded for each sample

3.3.6 Heavy metal analysis by using AAS: (APHA-3111 B, 1998).

Method followed for Heavy metal analysis was APHA-3111 B with slight modification.

3.3.6.1 Digestion of the sample:

For the digestion of water samples, 2-3 ml of Nitric acid was added to each of the sample.

3.3.6.2 Preparation of working standard solution:

1000ppm standard solution of lead was diluted to 100ppm and from 100ppm standard solution working standard solution of 1ppm 2ppm and 3ppm was made by diluting 100ppm solution in distilled water similar procedure was followed to make the working standard solution of 1ppm, 2ppm and 3ppm for iron, manganese, nickel and cadmium.

3.3.6.3 Instrumentation:

A Thermo scientific iCE 3000 AA was used for the FAAS measurement of iron, manganese nickel, lead and cadmium in different water samples. Each measurement was performed in triplicate. The final set of spectrometer parameters used is shown in table below:

Table 5 Instrument setting for iCE 3000 AAS.

Parameter	Iron	Manganese	Nickel	Lead	Cadmium
Wavelength	248.3nm	279.5nm	232.0	283.3	228.8
Lamp current	75%	75%	75%	75%	75%
Signal	Continuous	Continuous	Continuous	continuous	Continuous
Flame type	Air-Acetylene	Air-Acetylene	Air-Acetylene	Air-Acetylene	Air-Acetylene
Replicates	3	3	3	3	3

3.3.6.4 Calibration graph

Deionized water was used as a blank and accurately prepared working standard solution was used for the calibration graph. Calibration graph was obtained by plotting absorbance at y-axis and concentration at x-axis.

3.3.6.5 Sample analysis

In order to measure the concentration of heavy metals in drinking water sample. Absorbance of a sample was noted given by AAS. Absorbance of a sample was plotted in the calibration curve and the corresponding concentration of metals was found. All the samples were measured in triplicates and the average of the three values was taken.

4. Result and Discussion

The Government of Nepal gazette the National Drinking Water Quality Standard (NDWQS) in 2062 B.S as an effort to take first step towards assuring drinking water quality. So, it is essential to assess and compare the water quality parameters of drinking water of Tarahara with National Drinking Water Quality Standards 2062 and WHO.

This study assessed the physicochemical parameter of drinking water in Tarahara to identify the physical status, impurities and suspended solid that affects water for drinking purpose. The results of physical parameters in the tested samples are shown in table 6. Ground water temperature values in the study ranged from 27.4ºC to 28.3ºC with an average value of 27.54ºC. Highest temperature was found in the S4 with value 28.3ºC and the lowest temperature was found in S1 with value 27.4ºC. All the samples observed had average temperature and within the limit value.

The pH is an important water quality parameter. The pH ranging from 6.59-6.90 was observed in all tested samples. S4 has the most acidic pH value of 6.59 falling nearer to the lower level of guideline value. However, according to WHO and NDWQS the pH value between 6.5 and 8.59 usually indicates a good drinking water quality. The pH having less than 6.5 may cause corrosion of metal pipes thereby releasing toxic metals like Zn, Pb, Cd and Cu etc

Conductivity Values were recorded in between the range of 26.93-55.57 μS/cm with the average value of 39.2μS/cm. The least conductivity value was observed for the S2 with the value 26.93 μS/cm where as the highest conductivity value was observed for S4 with the value 55.57 μS/cm. According to WHO, EC value should not exceed 400 μS/cm (Meride and Ayenew, 2016). In our study area electrical conductivity varied between the ranges as mentioned by WHO which indicates that there is a low value of TDS in our sample as TDS is direct function of electrical conductivity.

TSS values were recorded within the range of 1.23 -3.27 mg/L with the average value of 2.40 mg/L. The highest TSS value was observed in S3 with the value 3.27mg/L while the lowest TSS value was observed in S2 with the value 1.23mg/L. According to WHO the permissible limits value for WHO is <30 mg/L (Reda, 2016). All the samples observed for TSS showed values within the guideline value. All the results of physical parameters showed that the water samples were fit for drinking purposes.

Table 6 Temperature, pH, conductivity and TSS of the water sample obtained from five different samples.

S.N	sample	Temperature(°c)	pH	ES(μ/cm)	TSS(mg/)
1	S1	27.4±0.20	6.67±0.006	48.17±1.26	2.17±0.12
2	S2	27.6±0.20	6.77±0.04	26.93±0.51	1.23±0.15
3	S3	28.1±0.17	6.60±0.33	32.70±0.20	3.27±0.12
4	S4	28.3±0.15	6.59±0.03	55.57±1.19	2.13±0.15
5	S5	26.3±0.15	6.91±0.01	32.70±0.36	3.20±0.20

Table 7 shows the concentration of heavy metals in the tested samples. The concentration of iron were found in between the range of 0.28 -10.47 mg/L. Least concentration value was observed in S2 with value 0.28mg/L where as highest concentration value was observed in S4 with value 10.47mg/L. Guideline value given by NDWQS for amount of iron in drinking water is <0.3 mg/L. Iron content was found to be more in all tested samples expect S2. High concentration of iron may be because of introduction of iron in drinking water from drinking water pipes since all drinking water pipes are made up of iron.

The concentration value of manganese were observed in between the range of <0.5 -1.91 mg/L. Here the least value was observed in S2 with value <0.5mg/L where as the highest value was observed in S4 with the value 1.19 mg/L. According to NDWQS amount of manganese in drinking water should be <0.2mg/L. Concentrations of Mn in three samples S1, S2, S5 were found within the guideline value but the two samples S4 and S1 were above the guideline value given by NDWQS. Since manganese is use in the manufacture of iron by which manganese can form coating on water pipes that may slough off as black precipitate (WHO, 2011), this may be one of the main reason for the for introduction of manganese in our drinking water samples**.**

Table 7. Concentration of heavy metals in the tested samples.

SN	Parameter	Unit	Result					Guideline value (NDWQC)
			S1	**S2**	**S3**	**S4**	**S5**	
1	Iron	mg/L	3.28	0.28	10.47	6.06	3.73	0.3
2	manganese	mg/L	0.34	<0.05	0.15	1.91	0.13	0.2
3	Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	-
4	Lead	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
5	Cadmium	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	0.003

In 2012, Aryal j and his team performed a research to find out the quality of drinking water in myagdi district. He found that arsenic concentration was within the range of 0.003-0.048mg/L in his all tested samples which was higher than NDWQS value whereas iron was found within the NDWQS value whereas this study found that iron and manganese concentration was found higher than than NDWQS value in most of the tested samples (S1, S3, S4, S5 for iron and S1, S4 for manganese). Similar type of research was performed by Ramchandra and his coworkers in various areas of hyderabad and found that concentrations of Pb, Cd and Cr were greater than the limit value where as in this study, concentration of Pb and Cd was with in the limit value.

Calibration graph of Iron, Manganese, Nickel, Lead and Cadmium.

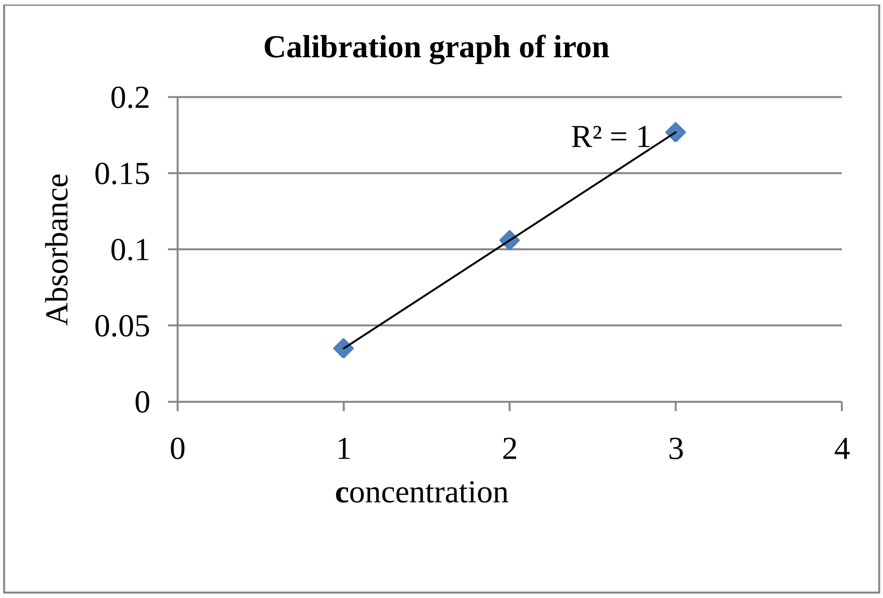

Fig. Calibration graph of iron

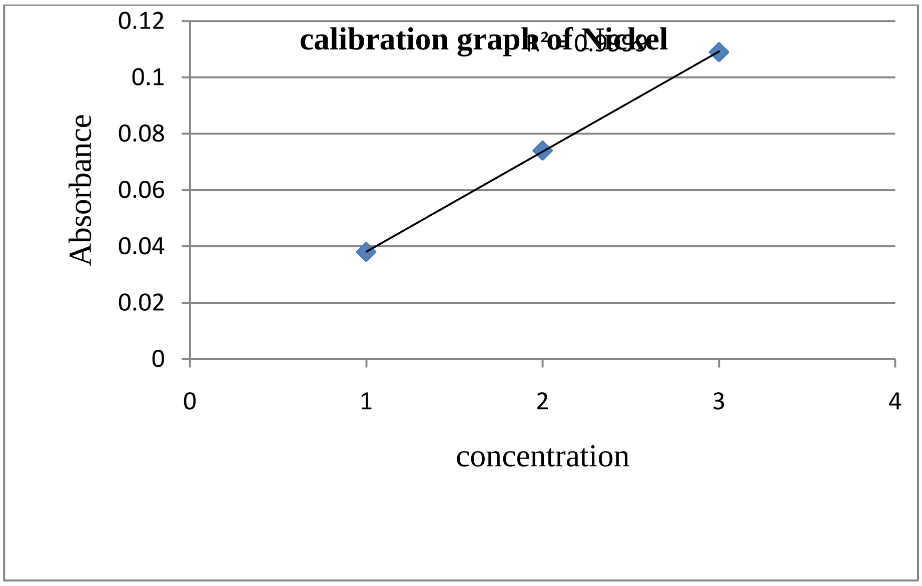

Fig calibration graph of Nickel

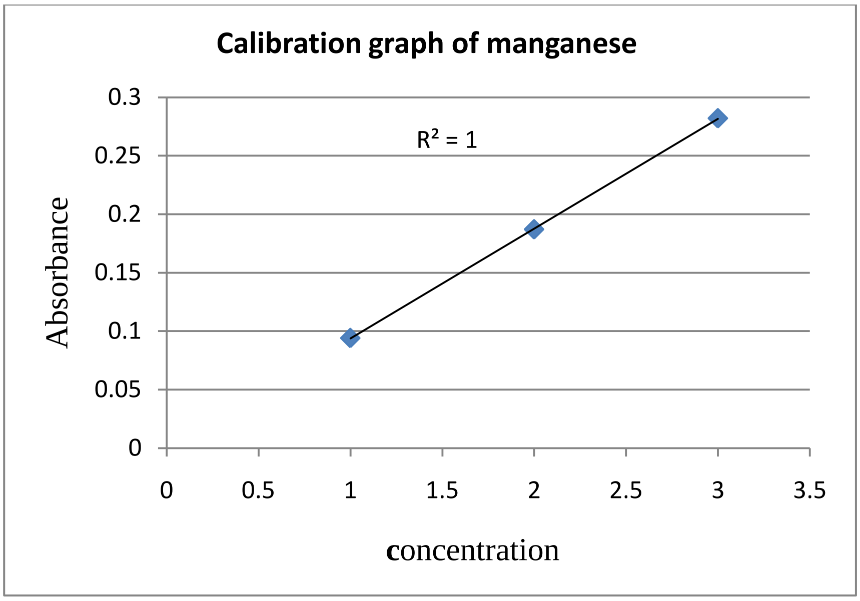

Fig Calibration graph of manganese

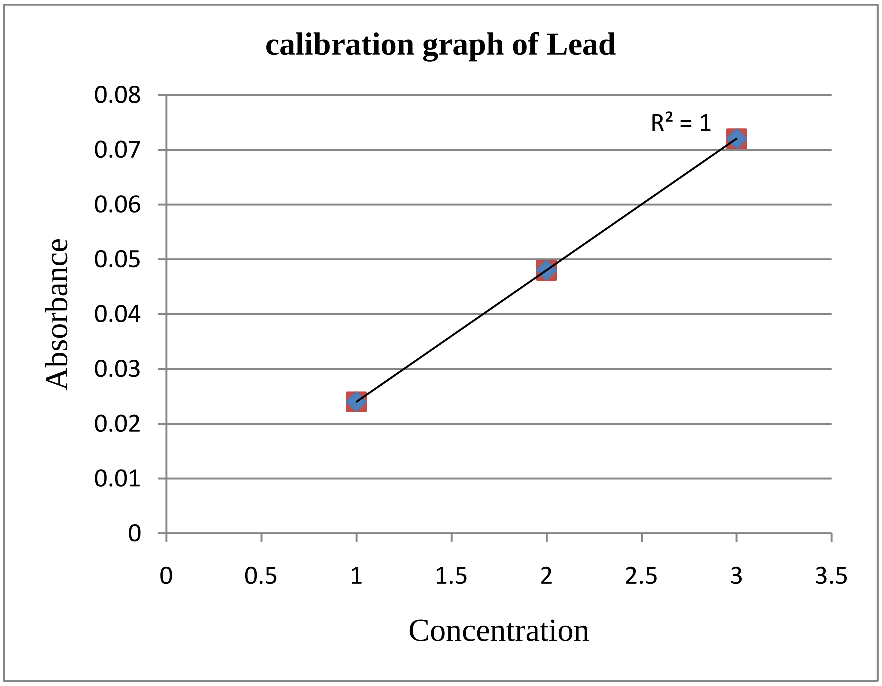

Fig. Calibration graph of lead

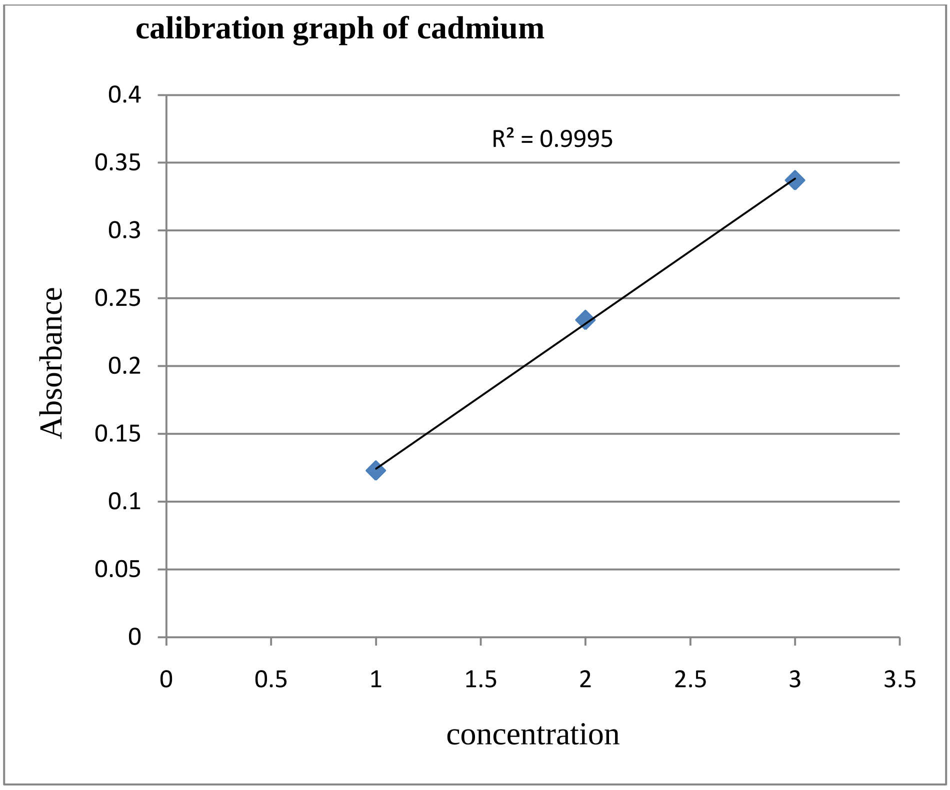

Fig. Calibration graph of Cadmium

5. Conclusion

According to data obtained from Physical test, all the result are within the limits i.e. pH (6.59-6.90), TSS (1.23-3.27 mg/L), ES (26.93-55.57 µs/cm) and temperature (27.4-28.3ºC) but the concentration of heavy metal especially iron is more than its limit in S1, S3, S4 and S5 with value 3.28, 10.47, 6.06 and 3.73mg/Lrespectively. Also, concentration of manganese were found more than its limit in S1 and S4 with value 0.34mg/L and 1.91mg/L respectively. The presence heavy metal with high concentration in water samples indicates that drinking such water can have adverse effect on health and may damage water and animal kingdom . So, it is highly recommended not to drink water of Tarahara without purification. Continual assessment and enlightment to the topic is highly essential.

6. Reference

Abbaspour, N., Hurrell, R., & Kelishadi, R. (2014). Review on iron and importance for human health. *Journal of Research in Medical Science,19*(2), 164-174.

Afshan, S., Ali, S., Ameen, U., Farid, M., Bharwana, S., Hannan, F., & Ahmad, R. (2014). Effect of Different Heavy Metal Pollution on Fish. *Research Journal of Chemical and Environmental Sciences,2*(1), 74-76.

Ahamed, M. M. (2012). Atomic Absorption spectroscopy. doi:DOI: 10.13140/RG.2.2.29580.51844

Ali, H., Khan, E., & Sajad, M. A. (2013). Phytoremediation of heavy metals—Concepts and applications. *Chemosphere,91*(7), 869-881. doi:10.1016/j.chemosphere.2013.01.075

Aryal, J., Gautam, B., & Sapkota, N. (2012). Drinking water Quality Assessment. *Journal Nepal Health Research Council,10*(3), 192-196.

Coates, T. D., & Cazzola, M. (2018). Introduction to a review series on iron metabolism and its disorders. *Blood,133*(1), 1-2. doi:10.1182/blood-2018-10-876466

Chowdhury, S., Mazumder, M. J., Al-Attas, O., & Husain, T. (2016). Heavy metals in drinking water: Occurrences, implications, and future needs in developing countries. *Science of The Total Environment*, *569-570*, 476–488. doi: 10.1016/j.scitotenv.2016.06.166

Das, S. K., Grewal, A. S., & Banerjee, M. (2011). A brief review: Heavy metal and their anaylsis. *Dept. of Pharmaceutical Analysis & Quality Assurance, Institute of Pharmacy & Technology,11*(1), 13-18.

Eaton, A. H. (1998). *Standard Method for the Examination of Water and Wastewater*. (L. s. clesceri & A. E. Greenberg, Eds.) (20th ed.). washington, DC: American Public Health Association.

Engwa, G. A., Ferdinand, P. U., Nwalo, F. N., & Unachukwu, M. N. (2019). Mechanism and Health Effects of Heavy Metal Toxicity in Humans. *Poisoning in the Modern World - New Tricks for an Old Dog?*doi:10.5772/intechopen.82511

Fakhri, Y., Jafarzadeh, S., Moradi, B., Zandsalimi, Y., Langarizadeh, G., Amirhajeloo, L., & Mirzaei, M. (2015). The Non-carcinogenic Risk of Cadmium in Bottled Water in Different Age Groups Humans: Bandar Abbas City, Iran. *Materia Socio Medica,27*(1), 52. doi:10.5455/msm.2014.27.52-55

Government of Nepal (2005).National Drinking Water Quality Standards. Ministry of Physical planning and Works. Singhadarbar,Kathmandu.

Hong, Y., Song, K., & Chung, J. (2014). Health Effects of Chronic Arsenic Exposure. *Journal of Preventive Medicine and Public Health,47*(5), 245-252. doi:10.3961/jpmph.14.035

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., & Beeregowda, K. N. (2014). Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology,7*(2), 60-72. doi:10.2478/intox-2014-0009

Järup, L. (2003). Hazards of heavy metal contamination. *British Medical Bulletin,68*(1), 167-182. doi:10.1093/bmb/ldg032

M, O., & M, S. K. (2016). Heavy Metals: Biological Importance and Detoxification Strategies. *Journal of Bioremediation & Biodegradation,07*(02). doi:10.4172/2155-6199.1000334

Manganese. (2013). *Nutritional and Environmental Medicine,*1-5. Retrieved from www.biolab.co.uk.

Manganese in drinking water. (2016). *Minnesota Department of Health,*1-2. Retrieved from www.health.state.mn.us.

Measuring TSS (Total Suspended Solids) in Water. (2019). Retrieved from https://www.rshydro.co.uk/water-quality-monitoring-equipment/water-quality-monitoring-parameters/tss-total-suspended-solids-water/

Meride, Y., & Ayenew, B. (2016). Drinking water quality assessment and its effects on residents health in Wondo genet campus, Ethiopia. *Environmental Systems Research,5*(1). doi:10.1186/s40068-016-0053-6

Mohod, C., & Dhote, J. (2013). Review of Heavy Metals In Drinking Water and their effect on human health. *International Journal of Innovative Research in Science, Engineering and Technology,2*(7), 2992-2996.

Nagajyoti, P. C., Lee, K. D., & Sreekanth, T. V. (2010). Heavy metals, occurrence and toxicity for plants: A review. *Environmental Chemistry Letters,8*(3), 199-216. doi:10.1007/s10311-010-0297-8

Nordberg, G. (2003). Cadmium and human health: A perspective based on recent studies in China. *The Journal of Trace Elements in Experimental Medicine,16*(4), 307-319. doi:10.1002/jtra.10039

Nowrouzi, M., Mansouri, B., Nabizadeh, S., & Pourkhabbaz, A. (2012). Analysis of heavy metals concentration in water and sediment in the Hara biosphere reserve, southern Iran. *Toxicology and Industrial Health,30*(1), 64-72. doi:10.1177/0748233712451767

Oram, M. (2014).Drinking water Testing and conductivity of Water. *Water Research Center*

Owa, F. (2014). Water pollution: Source, effects, control and management. *International Letters of Natural Science,3*, 1-6.

Oyem, H., Oyem, I., & Ezeweali, D. (2014). Temperature, pH, Electrical Conductivity, Total Dissolved Solids and Chemical Oxygen Demand of Groundwater in Boji-BojiAgbor/Owa Area and Immediate Suburbs. *Research Journal of Environmental Sciences,8*(8), 444-450. doi:10.3923/rjes.2014.444.450

Pandey, B., & Shakya, S. (2011). A comparative study of spring water and Ground water. *Rural Drinking Water Quality Status in Central Development Region,*(9), 52-56.

Pandey, G., & S., M. (2014). Heavy metal causing Toxicity in Animals and fishes. *Research Journal of Animal, Veterinary and Fishery Sciences,2*(2), 17-23.

Pavlovska, G., Stafilov, T., & Čundeva, K. (2015). Determination of iron in drinking water after its flotation concentration by two new dithiocarbamate collectors. *Journal of Environmental Science and Health, Part A,50*(13), 1386-1392. doi:10.1080/10934529.2015.1064285

Public Health Statement Nickel. (2005). *Agency for Toxic Substances and Disease Registry Division of Toxicology*. Retrieved from www.atsdr.cdc.gov.

Rai, P. K., Lee, S. S., Zhang, M., Tsang, Y. F., & Kim, K. (2019). Heavy metals in food crops: Health risks, fate, mechanisms, and management. *Environment International,125*, 365-385. doi:10.1016/j.envint.2019.01.067

Rahman, S. M., Kippler, M., Tofail, K., Bölte, S., Hamadani, J. D., & Vahter, M. (2017). Manganese inDrinkingWaterandCognitiveAbilitiesandBehaviorat10Yearsof Age: AProspectiveCohortStudy. *Environmental Health Perspectives*.

Ramakrishnah, C., Sadashibaiah, C., & Ranganna, G. (2009). Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India C. *E-Journal of Chemistry,6*(2), 523-530.

Reda, A. H. (2016). Physico-Chemical Analysis of Drinking Water Quality of Arbaminch Town. *Journal of Environmental & Analytical Toxicology,06*(02). doi:10.4172/2161-0525.1000356

Sharma, R. K., & Agrawal, M. (2005). Biological effects of heavy metals: An overview. *Journal of Environmental Biology,26*(3), 301-313.

Sharma, S. K., Poudel, B. R., & Sharma, H. R., Poudel. (2016). Electroanalytical Method. In *Concise Analytical Chemistry*(1st ed., pp. 149-170). Bhotahity, Kathmandu: National Book center

Shirkhanloo, H., Mousav, H. Z., & Rouhollahi, A. (2011). Preconcentration and determination of heavy metals in water, sediment and biological samples. *Journal of the Serbian Chemical Society,76*(11), 1583-1595.

Sidhu, M., & Brown, D. (1996). A New Laboratory Technique for Studying the Effects of Heavy Metals on Bryophyte Growth. *Annals of Botany,78*, 711-717.

Skalny, A. V. (2011). Bioelementology as an interdisciplinary integrative approach in life sciences: Terminology, classification, perspectives. *Journal of Trace Elements in Medicine and Biology,25*. doi:10.1016/j.jtemb.2010.10.005

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy Metal Toxicity and the Environment. *Experientia Supplementum Molecular, Clinical and Environmental Toxicology,*133-164. doi:10.1007/978-3-7643-8340-4_6

THE Electrical conductivity of Water. (2018). Retrieved from https://www.smart-fertilizer.com/articles/electrical-conductivity

Total suspended solids. (2018). *Science Direct*. Retrieved from https://www.sciencedirect.com/topics/engineering/total-suspended-solid.

Turbidity, Total Suspended Solids & Water Clarity. (2019). Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

UNICEF (2008). UNICEF HandBook on Water Quality, New York, United Nations Children’s fund

USEPA.(2004).Drinking water Health Advisory for manganese. Retrieved from http://www.epa.gov/safewater

Waldvogel-Abramowski, S., Waeber, G., Gassner, C., Buser, A., Frey, B. M., Favrat, B., & Tissot, J. (2014). Physiology of Iron Metabolism. *Transfusion Medicine and Hemotherapy,41*(3), 213-221. doi:10.1159/000362888

Wessling-Resnick, M. (2017). Excess iron: Considerations related to development and early growth. *The American Journal of Clinical Nutrition,106*(Supplement 6). doi:10.3945/ajcn.117.155879

WHO (2011) Cadmium in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality. Geneva, World Health Organization (WHO/SDE/WSH/03.04/80)/Rev/1

WHO(2019). Drinking Water. Fact sheet. World Health Organization.

WHO Guidelines for drinking-water quality. Geneva, World Health Organization (WHO/SDE/WSH/03.04/08).

WHO (2011) Lead in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality. Geneva, World Health Organization (WHO/SDE/WSH/03.04/09)/Rev/1

WHO(2018) Lead Poisoning and health. Fact sheet. World Health Organization

WHO (2005)Nickel in drinking- water. Background document for preparation of WHO Guidelines for drinking-water quality. Geneva, World Health Organization (WHO/SDE/WSH/05.08/55).

WHO (2003) pH in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality. Geneva, World Health Organization (WHO/SDE/WSH/03.04/12).

Yeazdani, S. (2016). State of drinking water and its management aspects in Dhaka city. *Journal of Nepal Geological Society,50*, 59-64.

Zambelli, B., & Ciurli, S. (2013). Nickel and Human Health. *Metal Ions in Life Sciences Interrelations between Essential Metal Ions and Human Diseases,*321-357. doi:10.1007/978-94-007-7500-8_10

Zhong, W., Ren, T., & Zhao, L. (2016). Determination of Pb (Lead), Cd (Cadmium), Cr (Chromium), Cu (Copper), and Ni (Nickel) in Chinese tea with high-resolution continuum source graphite furnace atomic absorption spectrometry. *Journal of Food and Drug Analysis*,*24*(1), 46-55. doi:10.1016/j.jfda.2015.04.010

7. Appendices

Photo Gallary

Fig: Sample Source

Fig: Sample

Fig: Atomic Absorption Spectroscopy

Fig: pH meter

Fig: Digital balance

Fig: Hollow Cathode Lamp

Fig: Conductometer