Removals of Heavy Metals from Bed Sediment of Brahmani River

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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In
Civil Engineering

BY

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UNDER THE GUIDANCE OF

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CERTIFICATE

This is to certify that the Project Report entitled "**Removal of Heavy Metals from Bed sediment**" submitted by **Mr. Mukul Mahato** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in **Civil Engineering** at National Institute Of Technology, Rourkela (Deemed University) is an authentic work carried out by them under our supervision and guidance.

To the best of our knowledge, the matter embodied in this Project Report has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date-

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My heart pulsates with the thrill for tendering gratitude to those persons who helped me in completion of the project.

The most pleasant point of presenting a thesis is the opportunity to thank those who have contributed to it. Unfortunately, the list of expressions of thank no matter how extensive is always incomplete and inadequate. Indeed this page of acknowledgment shall never be able to touch the horizon of generosity of those who tendered their help to me.

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MUKUL MAHATO

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ABSTRACT:

The presence of heavy metals in river water, which is regular in mechanical and urban ranges including mining commercial ventures, represents a destructive impact to human wellbeing and nature's domain. There is a high probability of pollution of both surface and river water because of the release of heavy metal polluted wastewater. Evacuation of such heavy metals has been an examination center to plan a productive medicine framework. Some late innovations that address this issue are prone to be extremely unreasonable. Anyway here we are attempting to evacuate these heavy metals specifically from river water.

Before removals these heavy and harmful metals we are first determining the physical characteristics of the bed sediment for each site. This will give us the ideas about the differences in physical characteristics for the different sites of the same river as well as the particle sizes distributions in the bed sediment.

Removals of heavy metals can be done using many methods. Many of those are very expensive. One of the simplest methods to remove these metals is **Adsorption method.** *These metals can be directly adsorbed by using proper adsorbent. For different metals adsorbent may be different, but in some cases two or more metals can be adsorbed by same adsorbent. For different pH the efficiency of adsorption is different but we are removing these metals directly from river bed sediment, so all the experiment are done in natural pH.*

CHAPTER -1

INTRODUCTION

Numerous dissolved metals have been found in extremely destructive concentrations in river bound for consumable drinking water because of both regularly happening pollution and also tainting presented from modern contaminations. The concentration of any of these contaminants makes some level of wellbeing concerns running from extremely mellow to extreme.

Consistent expanding urbanization and water request in regions of modern movement has expanded the recurrence of issue metals in river sources. In little amounts, certain heavy metals are healthfully crucial for a solid life, however a lot of these metals may cause intense or perpetual danger or harming. Follow components, for example, iron, arsenic, copper, manganese, and zinc are generally discovered commonly in sustenances we devour or as a feature of a vitamin supplement. Heavy metals are additionally a piece of the assembling methodology of numerous normal family things, for example, pesticides, batteries, electroplated metal parts, material colors and steels.

The metals regularly connected to human harming have connections to taking in inabilities like growths and passing are normally copper, nickel, cadmium, chrome, arsenic, lead and mercury. Many of these metals are needed by people in little sums however in bigger, industrious measurements, these heavy metals get dangerous when they are not metabolized by the body and gather in the delicate tissues. Heavy metal danger can bring about harmed or diminished mental and focal apprehensive capacity, easier vitality levels, and harm to blood arrangement, lungs, kidneys, and other crucial organs.

Different ease-adsorbents, determined from rural squanders, mechanical by-items, regular materials, or altered biopolymers, have been as of late created and petitioned the evacuation of heavy metals from metal-defiled wastewater by extremely routines. For the most part, there are three fundamental steps included in toxin sorption onto robust sorbent:

(i) The transport of the poison from the mass answer for the sorbent surface;
(ii) Adsorption on the molecule surface; and
(iii) Transport inside the sorbent molecule.

Specialized appropriateness and expense-adequacy are the key components that assume significant parts in the determination of the most suitable adsorbent to treat inorganic effluents.

1.1 ADVANTAGES:

1. Removals of toxic elements can be done directly.
2. Provides high quality water, soft and low in minerals
3. It can be easily performed in the laboratory.
4. According to the concentration of these metals, water can be used in irrigation according to its requirement.
5. This method can be used in the rural areas where people directly drink water from river or ground.

1.2 OBJECTIVES

1. Bed sediments have been collected from two different sites of Brahmani river located at Rourkela.
2. Physical properties of the sediments have been determined and shown in chapter 5 (with tables and graphs).
3. Concentrations of toxic and heavy metals have been determined and shown in the chapter 5 (with tables and graphs).
4. Removals of these metals have been done using Adsorption methods and shown in chapter 5 (with tables and graphs).

CHAPTER 2

LITERATURE REVIEW

2.1 General Parameters

The metals are considered "Heavy Metals" in the event that they have a particular gravity > 5 g/cm3 in their standard state. There are about sixty known heavy metals and can aggregate about whether in soils and plants and could have a negative impact on physiological exercises of plants, bringing on diminishments in plant development, dry matter gathering and yield, Devkota and Schmidt, 2000 [1]. There are numerous terms used to depict and order metals, including follow metals, move metals, micronutrients, lethal and heavy metals. A large number of these definitions are discretionary and these terms have been utilized inexactly as a part of the writing to incorporate components that don't strictly meet the meaning of the term. Metals are characterized as a component that has a gleaming brilliance and is a great transmitter of hotness and power,Mclean and Bledsoe, 1992 [2]. In soil, metals are found in one or a greater amount of a few "pools" of the dirt, as depicted by Shuman (1991) [3]:

• Dissolved in the dirt result

• Occupying trade locales in inorganic soil constituents

• Specifically adsorbed in inorganic soil constituents

• Associated with insoluble soil natural matter

• Precipitated as unadulterated or blended solids

• introduce in the structure of auxiliary minerals and

2.2 Physical Characteristics

For examining the heavy metals in soils Wu et al. 2007 [4] found that the between-relationship between heavy metals and dynamic soil parts, (for example, Fe oxides, natural matter, and earth) is the significant prescient component and they reasoned that the correspondence with aggregate Fe (counting dynamic and leftover Fe) is the real system. In a study led by Chen et al. 1999 [5] it was recommended that concentrations of most follow metals in Florida soils are essential controlled by soil properties, Clay, natural C content, and CEC demonstrated critical relationship with concentrations of most follow metals where the soil pH had noteworthy positive connection with concentrations of As, Cd, Cr, Cu, Mn, Se, and Zn. Adsorption of metal cations has been associated with such soil properties as pH, redox potential, mud, soil natural matter, Fe and Mn oxides, 18 and calcium carbonate content Mclean and Bledsoe, 1992. Heavy metal motion in soils are mind boggling and affected by various components, for example, the pH, soil natural matter, soil surface, redox potential, and temperature Alloway, 1991 [6]. Additionally high calcium fixation in the treated soils can altogether obstruct the metal transport, in light of the fact that the movement and precipitation of calcium as bicarbonates and hydroxides can stop up soil pores and increment the soil support limit, compelling the development of the corrosive front REDDY et al., 2006; DE GIOANNIS et al., 2007c [7].

2.3 Chemical Compositions

The connection between soil pH and heavy metal limit qualities reflects the complex communication between heavy metals and the different soil properties Gawlik and Bidoglio, 2006 [8]. pH is a measure of the hydrogen particle focus causticity or alkalinity of the soil. Measured on a logarithmic scale, a soil at pH 4 is 10 times more acidic than a soil at pH 5 and 100 times more acidic than a soil at pH 6. Alkalinity is typically an intrinsic normal for soils, in spite of the fact that watering system can build the alkalinity of saline soils. Soils made antacid by calcium carbonate alone once in a while have pH values over 8.5 and are termed 'calcareous'. Under ordinary conditions the most alluring pH range for mineral soil is 6.0 to 7.0 and 5.0 to 5.5 for natural soil. The cushion pH is a quality utilized for deciding the measure of lime to apply on acidic soils with a pH short of what 6.6. Builds in soil pH can happen as the consequence of natural matter deterioration, on the grounds that mineralization and ammonification methods discharge OH^- particles and expend H^+ particles, Ritchie and Dolling, 1985 [9]. Colloid and metal portability, was improved by reductions in result pH and colloid size, and builds in natural matter, which brought about higher elution of sorbed and solvent metal loads through metal–organic complex arrangement, Karathanasis et al., 2005 [10].

CHAPTER - 3

THE STUDY AREA

3.1 River Site locations

Brahmani River

The **Brahmani** is a major river in the Odisha state of Eastern India. The Brahmani is formed by the confluence of the Sankhand South Koel rivers, and flows through the districts of Sundargarh, Kendujhar, Dhenkanal, Cuttack and Jajapur. Together with the rivers Mahanadi and Baitarani, it forms a large delta before entering into the Bay of Bengal at Dhamra. The Brahmani is formed by the confluence of the rivers South Koel and Sankh near the major industrial town of Rourkela at 22 15'N and 84 47' E.

Figure 1. Jhirpani Site

Figure 2. Panposh site

Soil sample was taken from Jhirpani in the month of July 2014. Within a certain area many samples have been collected. Same work have been done for Panposh site in the month of November 2014.

3.2 Bed Sediment and Its Characteristics

Bed Sediment of a river is the soil some piece of the river which is discovered simply beneath the water. It is a characteristically happening material that is broken around techniques of weathering and disintegration and is consequently transported by the water. By and large, dregs transported by water happens by fluvial procedure. Shore sands and river channel stores are normal samples of fluvial transport and statement, however because of low speed of water stream bed dregs are likewise found in seas and lakes. Dregs is for the most part grouped on the premise of its grain size and its sytheses. Dregs size is measured on a log2 scale (Phi scale), which arranges molecule size from "colloid" to "stone".

There are numerous properties which characterizes soil's physical condition like grain size circulation, ideal dampness content, penetrability, density and so forth. Soil surface is controlled by the relative extent of the three sorts of soil particles, called soil differentiates:

- sand
- silt, and
- clay

Bigger soil structures are called peds. These are made from the divides when iron oxides, carbonates, earth, and silica with the natural constituent humus, cover particles and reason them to follow into bigger, moderately steady auxiliary structures. Soil density (mass density), is a measure of soil compaction. Soil porosity comprises of the piece of the soil volume possessed by gasses and water. Soil consistency is the capacity of soil which demonstrates the stick conduct of soil together. Soil temperatures and colors are portraying toward oneself. The properties of the bed dregs change through the profundity of a soil profile.

3.3 Adsorption of Heavy Metals

Soil defilement or soil contamination is created by the vicinity of human-made (xenobiotic) chemicals or other adjustment in the regular nature's turf. It is regularly brought about by industrial action, farming chemicals, or ill-advised transfer of waste. The most well-known chemicals included are petroleum hydrocarbons, polynuclear fragrant hydrocarbons, (for example, naphthalene and benzo(a)pyrene), solvents, pesticides, lead, and other heavy metals. Defilement is corresponded with the level of industrialization and force of concoction utilization. The worry over soil pollution stems principally from wellbeing dangers, from immediate contact with the tainted soil, vapors from the contaminants, and from auxiliary tainting of water supplies inside and underlying the soil. Mapping of defiled soil destinations and the ensuing cleanup are lengthy and unreasonable undertakings, obliging broad measures of topography, hydrology, chemistry, machine demonstrating abilities, and GIS in Environmental Contamination, and in addition an energy about the historical backdrop of industrial chemistry.

Adsorption is a process that happens when a gas or fluid solute aggregates on the surface of a strong or a fluid (adsorbent), shaping an atomic or nuclear film (the adsorbate). Adsorption is agent in most regular physical, biotic, and concoction frameworks, and is generally utilized within industrial provisions, for example, initiated charcoal, manufactured gums and water purging. Medicines are carried out by dealing with time and focus. A sufficient measure of adsorbent is utilized and shaked as a part of shaker. Following one hour some amount of the water is taken out and rest is considered further shaking. Following one hour same strategy is carried out etc. Following 8 hour the adsorption is very nearly in most extreme condition. After this is discovered to be steady. Consequently before 8 hour all readings are taken and chart are plotted between time and focus. From the understanding we can discover the rate evacuations of the heavy metals.

CHAPTER - 4

METHODOLOGY

4.1 PHYSICAL CHARACTERISTICS

Before removals of heavy metals, the physical parameters of the bed sediments have been determined. Some common and major tests have been done:

4.1.1 Field Moisture Content

Field moisture content shows the quantity or percentage of water that the soil contains. Three samples were taken and weight of each sample was measured. Then the samples were left in oven at a constant temperature of 105ºC. After 24 hours, completely dried, the weight of each samples was measured. The moisture content is expressed as

$$\mathbf{w = (W_S/W_W)\ x100} \qquad (1)$$

Where,

W_w = weight of water in soil mass

W_s = weight of dry soil

w = moisture content

4.1.2 Specific Gravity

Specific gravity is the proportion of the density of a substance to the density (mass of the same unit volume) of a reference substance. The reference substance is about constantly taken as water for fluids or air for gasses.. In the wake of sieving the stove dried soil through 425 micron strainer, 100g of specimen was taken in two diverse pycnometer and specific gravity of each one examples was measured, as shown in Figure 3a and 3b.

Figure 3a. Pycnometer

Figure 3b. Digital Weight Machine

Figure 3. Specific Gravity Measurement

The specific gravity is expressed as

$$G=\frac{w2-w1}{(w2-w1)-(w3-w4)} \qquad (2)$$

Where,

w1= weight of pycnometer (g)

w2= weight of pycnometer + soil (g)

w3= weight of pycnometer + soil + water (g)

w4= weight of pycnometer + full of water (g)

4.1.3 Atterberg Limit Indices or Consistency Limits

Consistency denotes degree of firmness of a soil which may be termed as soft, firm, stiff or hard. In 1911, depending on the water content of the soil, the Swedish agriculture Atterberg divided the entire range into four stages:

i. The liquid state
ii. The plastic state
iii. The semi-solid state
iv. The solid state

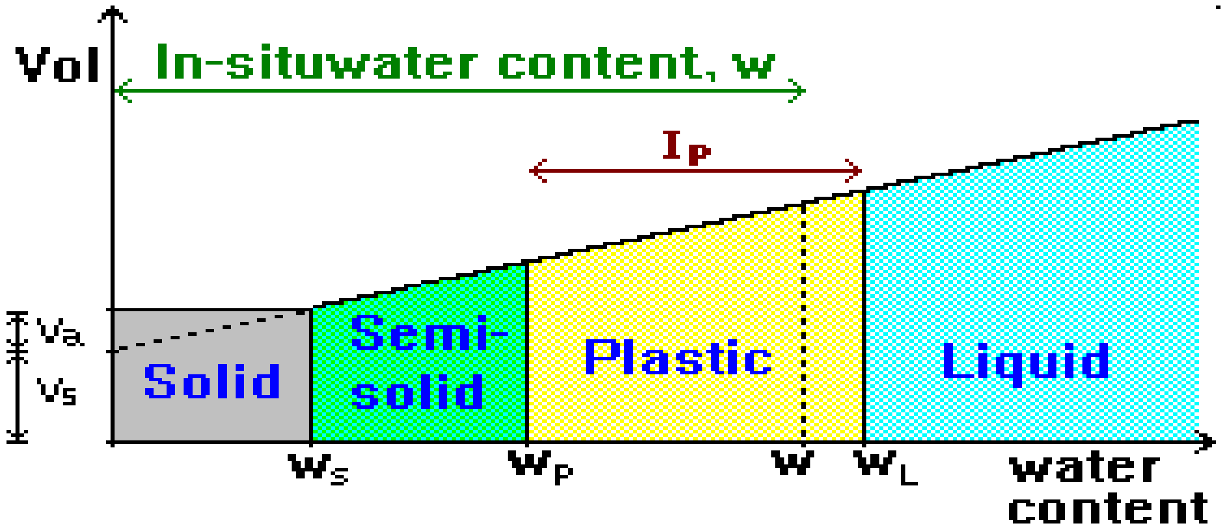

Figure 4. Consistency Limits

In each one state, the consistency and conduct of a soil is diverse. Subsequently, the limit between each one state could be characterized focused around a change in the soil's conduct. As far as possible could be utilized to recognize whether the soil is residue or mud, and it can recognize diverse sorts of sediments and dirts. For a far reaching soil, the soil will start to swell if the dampness content is surpassed. In the event that we expand the water content past the soil's plastic point of confinement the soil will be changed into a flexible, plastic mass, which causes extra swelling. The soil will stay in the plastic state until its liquid cutoff is surpassed, which makes it convert into a gooey liquid that streams when jolted. Four separate sorts of research center tests are carried out.

Liquid limit

The liquid limit is often conceptually defined as the water content at which the behavior of a clayey soil changes from plastic to liquid. The liquid limit test is used to classify soils. Different soils have varying liquid limits. It is also used to determine the plasticity index of a soil. Liquid limit is determined by using Casagrande's apparatus.

Liquid limit (LL) of a soil sample can be expressed as,

$$W_L = w\,(N/25)^e \qquad (3)$$

Where,

w= water content (%) corresponding to N blows

N= No. of blows

e= 0.092 for W_L<50

= 012 for W_L>50

For average value of 0.1 is taken for practical purposes.

Figure 5. Casagrande's Apparatus

Plastic limit

Plastic breaking point is the water content comparing to a discretionary utmost between the plastic and the semi-strong states of consistency of a soil. It is characterized as the base water content at which a soil will simply start to crumble when moved into a thread roughly 3mm in width. The methodology is characterized in ASTM Standard D 4318.

Shrinkage Limit

As far as possible (SL) is the water content where further misfortune of dampness won't bring about any more volume decrease. The test to focus as far as possible is ASTM International D4943. As far as possible is considerably less ordinarily utilized than the liquid and plastic cutoff points. It is the base water content at which a soil is still in soaked condition.

Plasticity Index

The plasticity index (PI) is a measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit.

$$I_p = LL-PL \quad (4)$$

Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay.

PI and their meanings

- (0-3)- Non-plastic
- (3-15) - Slightly plastic
- (15-30) - Medium plastic
- >30 - Highly plastic

4.1.4 Grain Size Distribution

Grain size examination of a soil characterizes the relative sum (by mass) of particles present agreeing in the soil. It influences the quality and burden-bearing properties of soils. The particles size conveyance is found by Sieve Analysis. This system is utilized due to its straightforwardness, affordability, and simplicity of translation. These strainers are organized as per its sizes. Each one sifter are shaken impeccably and the weight held at each one strainer is measured, as shown in figure 6.

Figure 6. Sieve Analysis

4.1.5 Optimum Moisture Content

The Optimum Water Content of soil is the water content at which a most extreme dry unit weight could be attained. It is carried out by giving compaction exertion. A max dry unit weight might be when zero voids are in the soil. For compaction of any specific soil in the field, the designer can fluctuate water content, measure of compaction, and sort of compaction. By and large, OMC is dictated by utilizing standard delegate test or adjusted delegate test. It is done using Standard Compaction Test apparatus, as shown in figure 7. Around 2.5 kg of stove dried of soil is taken. At first 150 ml of water is included and compaction is carried out. The density is measured and some soil example is taken and kept in stove. 50 ml water is added to the rest example and same procedure is carried out. This is defeated 5 examples. The dry density of the soil is given by:-

$$\gamma_d = \gamma_t / (1+w) \qquad (5)$$

Where,

γ_t= wet density of soil

γ_d= dry density of soil

w= moisture content

Figure 7. Standard Compaction Apparatus

4.1.6 Direct Shear Test

A **direct shear test** is a laboratory or field test used by geotechnical engineers to measure the shear strength properties of soil. The shear force, F, at failure, corresponding to the normal load N is measured with the help of the proving ring. A number of identical specimens are tested under increasing normal loads and the required maximum shear force is recorded. A graph is plotted between the shear force F as the ordinate and the normal load N as the abscissa. Such a plot gives the failure envelope for the soil under the given conditions. According to the graph cohesion (c) and ϕ are determined.

The shear strength is determined by

$$\mathbf{S = \sigma \tan\phi + c} \qquad (6)$$

Where,

σ =Normal Stress (kg/cm^2) **c**=cohesion (kg/cm^2)

s=Shear strength of soil (kg/cm^2) **ϕ**=Angle of shearing resistance

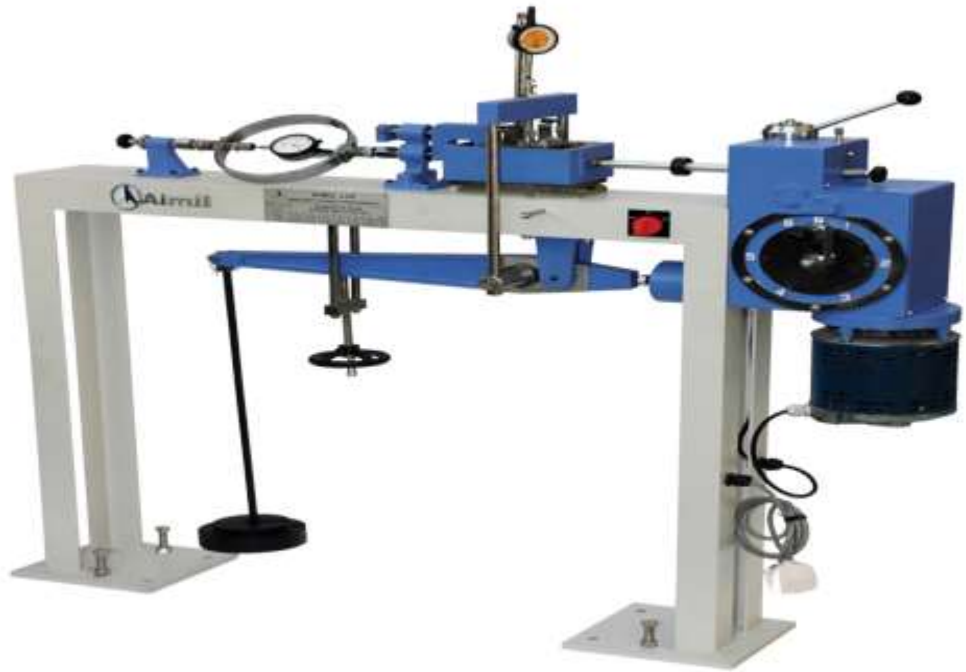

Figure 8. Direct Shear Test Apparatus

4.1.7 pH value

The soil pH is a measure of the acridity or basicity in soils. It goes from 0 to 14, with 7 being unbiased. A pH underneath 7 is acidic or more 7 is fundamental. Impacts of pH on adsorption and evacuation proficiency of ionizable natural mixes (IOCs) by ecological adsorbents are a zone of verbal confrontation, due to its double intervention towards adsorbents and adsorbate. Some soil is taken in a measuring glass and shaken for ½ hours consistently. The example is then left for 24 hours to get totally settled. After complete settlement the water is gathered and pH is measured.

Figure 9. pH meter

4.2 HEAVY METALS

Metal toxicity is the dangerous impact of specific metals in specific structures and measurements on life. A few metals are harmful when they structure noxious solvent mixes. Certain metals have no natural part, i.e. are not crucial minerals, or are dangerous when in a certain structure. On account of lead, any measurable sum may have negative wellbeing impacts. Frequently heavy metals are thought as synonymous, however lighter metals might additionally be poisonous in specific circumstances, for example, beryllium, and not all heavy metals are especially lethal, and some are crucial, for example, iron. The definition might additionally incorporate follow components when acknowledged in anomalous high, dangerous dosages.

Water is additionally a significant supply of these metals. Henceforth, we must deal with the water quality and check the centralization of these metals. In the event that it is in high fixation evacuation must be carried out.

4.2.1 Iron

Iron is a compound component with the image Fe (from Latin: ferrum) and nuclear number 26. It is a metal in the first move arrangement. It is the fourth most normal component in the Earth's covering. A sufficient measure of iron is required to human body. It gives great quality and wellbeing. Anyway after a certain breaking point of dosages it can result in negative impact called Iron Poisoning.

Iron harming is an iron over-burden brought on by a vast overabundance of iron admission and normally alludes to an intense over-burden as opposed to a slow one. The term has been basically connected with junior kids who expended vast amounts of iron supplement pills, which take after desserts and are generally utilized, including by pregnant ladies—see over nourishment (roughly 3 grams is deadly for a 2 year old).

4.2.2 Arsenic

Iron is a compound component with the image Fe (from Latin: ferrum) and nuclear number 26. It is a metal in the first move arrangement. It is the fourth most regular component in the Earth's hull. A sufficient measure of iron is required to human body. It gives great quality and wellbeing. In any case after a certain utmost of dosages it can result in negative impact called Iron Poisoning.

Iron poisoning is an iron over-burden brought about by an extensive overabundance of iron admission and generally alludes to an intense over-burden as opposed to a progressive one. The term has been fundamentally connected with youthful kids who devoured huge amounts of iron supplement pills, which look like desserts and are generally utilized, including by pregnant ladies—see over nourishment (more or less 3 grams is deadly for a 2 year old

Adsorbent Used:

Cement mortar :- cement mortar is casted and left for settle in air and then for oven dry.

w/c ratio= 0.45

Procedure:

Each soil samples are taken in beakers and cement mortar is crushed properly and entered into the beaker.

Quantity of sample= 75 ml each

concentration= 15g/l

Hence, quantity of cement mortar= 15×75/1000 = 1.125 g

For properly crushing, it is kept on magnetic stirrer for 2 hours. After that the samples are kept in shaker and left for shaking. After one hour, some quantity of water is taken out and again the beakers are allowed for further shaking. After one hour same procedure is done. Same method is done in the interval of one hour. After 8 hours the adsorption is considered as maximum and the experiment is stopped.

Figure 10a. Magnetic Stirrer

Figure 10b. Shaker

Figure 10c. Atomic Absorption Spectroscopy

Figure 10. Apparatus used for Adsorption

Efficiency $$\eta = \frac{C_i - C_o}{C_i} \qquad (7)$$

Where, C_i = Initial Concentration

C_o = Final Concentration

CHAPTER - 5

RESULTS

5.1 Field Moisture Content

Field moisture content obtained using equation 1, is shown in Figure 11 for both the soil samples collected from Jhirpani and Panposh.

The results indicate moisture content at Jhirpani is 13.899 % which is less than Panposh 33.631.

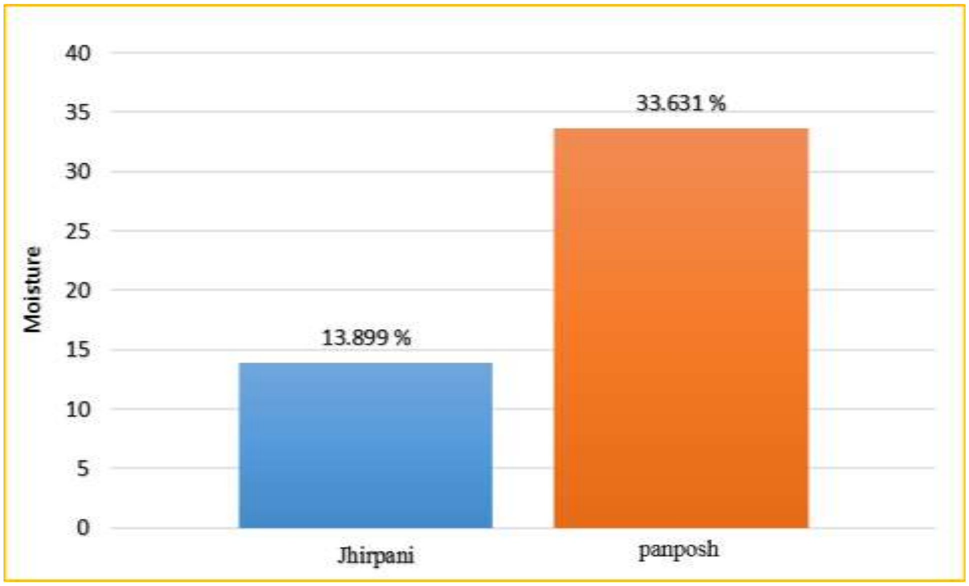

Figure 11. Moisture Content

5.2 Specific Gravity

It is determined by the equation 2 and it is shown in the Table 1. The results show that the specific gravity of Panposh soil is greater than Jhirpani soil.

site	Sample 1	Sample 2	Final
Jhirpani	2.390	2.404	2.397
Panposh	2.62	2.55	2.585

Table 1. Specific gravity

6.3 Atterberg Limit Indices or Consistency Limits

5.3.1 Plastic Limit

Plastic Limit is determined by equation 3 and shown in the Table 2 and Figure 12. The Plastic limit of Jhirpani and Panposh samples is taken by the semi-log graph plotted between No. of rotation and moisture content.

Site	N=24	N=26	N=30	N=25
Jhirpani	25.920	21.926	20.026	24.000
Panposh	23.600	23.210	23.260	22.500

Table 2. Liquid Limit

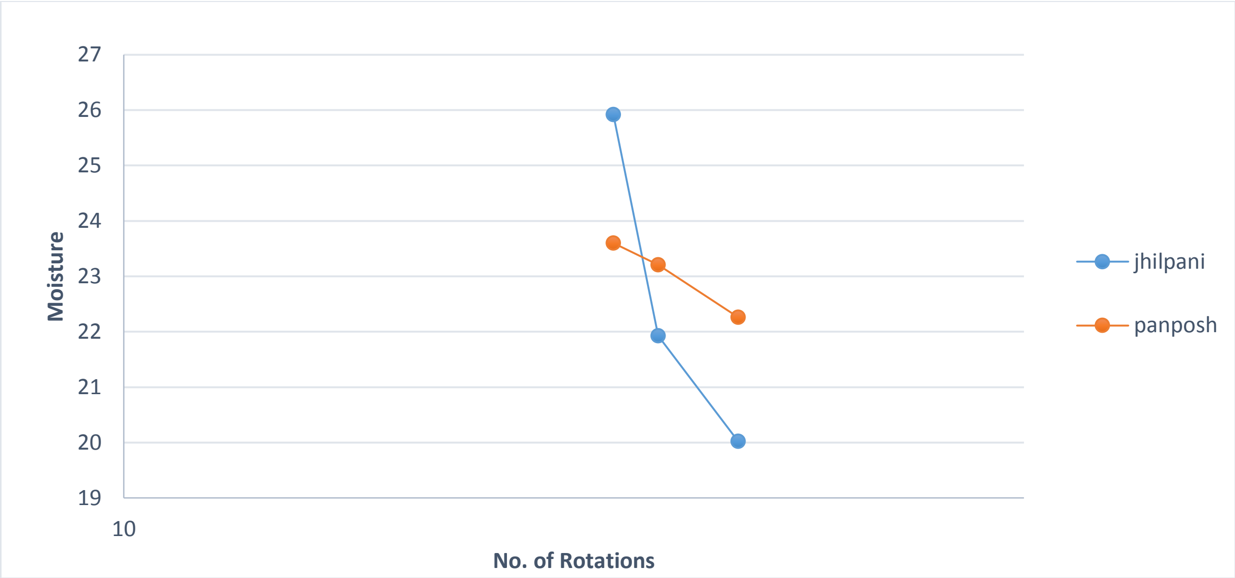

Figure 12. Liquid Limit Graph

The graph is plotted in a semilog scale in x-axis. It shows the number of rotations and the graph comes out to be linear. Using the graph at N (number of rotations) =25 the OMC for each sample is determined.

By using the graph, OMC of Jhirpani sample is found as 24 % which is slightly greater than Panposh sample 22.5 %.

5.3.2 Plastic Limit

Plastic limit is determined by rolling the soil sample in small thread (around 3mm diameter). At this stage the moisture content by the soil is known as plastic limit and is shown in the table 3.

Site	Sample 1	Sample 2	Sample 3	Plastic Limit
Jhirpani	-	-	-	-
Panposh	15.67%	14.10%	15.02%	14.93%

Table 3. Plastic limit

5.3.3 Plasticity index

The plasticity is determined by the equation 4. The plasticity index of the Jhirpani sample is found as 0 while the PI of the Panposh sample is determined as 7.6. Which shows that the Jhirpani sample is totally free of clay and Panpos sample has small quantity of clay particles.

5.4 Grain Size Distribution

Grain size distribution is determined by sieve analysis. 1 kg of each sample is taken and the percentage retained is shown in the figure 13.

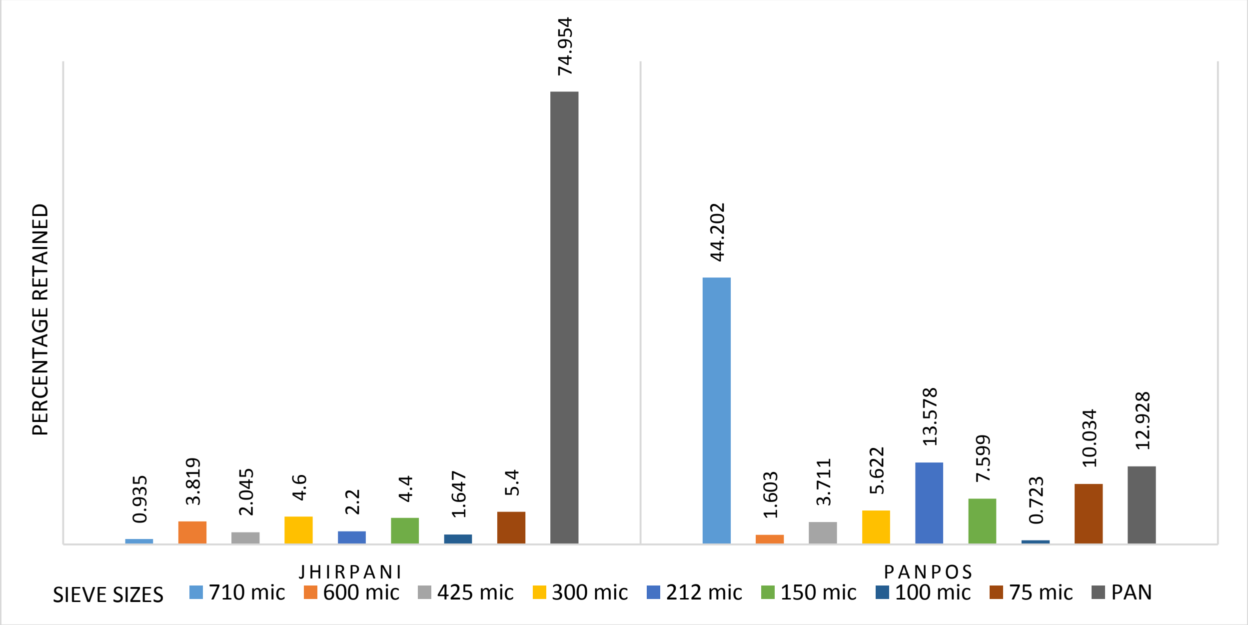

Figure 13. Sieve Analysis

From figure 13 it can be seen that for Jhirpani sample maximum of the soil particles are passing through 75 micron sieve (around 75%). Hence, the soil is classified as very fine graded silty soil and for Panpos sample the particles distribution is approximately uniform. Hence, it is classified as well graded soil.

5.5 Optimum Moisture Content

The test has been done for 5 different samples for each site. The dry density for each sample can be determined by using the equation 5.The results have been shown in the table 4 and 5 its corresponding graph in the figure 14 and 15 respectively for Jhirpani and Panposh.

DETERMINATION NO.	1	2	3	4	5
Wt of mould + compacted soil(kg)	3.838	3.900	3.848	3.838	3.768
Wt of compacted soil(kg)	2.05	2.11	2.06	2.04	1.98
Wet density(g/cc)	2.05	2.11	2.06	2.04	1.98
Cruble wt(g)	12.40	11.84	12.49	12.20	12.37
Wt of cruble+wet soil(g)	45.80	56.90	35.00	38.40	44.60
Wt of cruble+dry soil(g)	42.65	52.04	32.32	34.73	39.28
Wt of water(g)	3.15	4.86	2.68	3.67	5.32
Water content (%)	10.6	12.1	13.6	16.4	19.75
Dry density(g/cc)	1.85	1.88	1.82	1.753	1.65

Table 4. Standard Compaction Test for Jhirpani

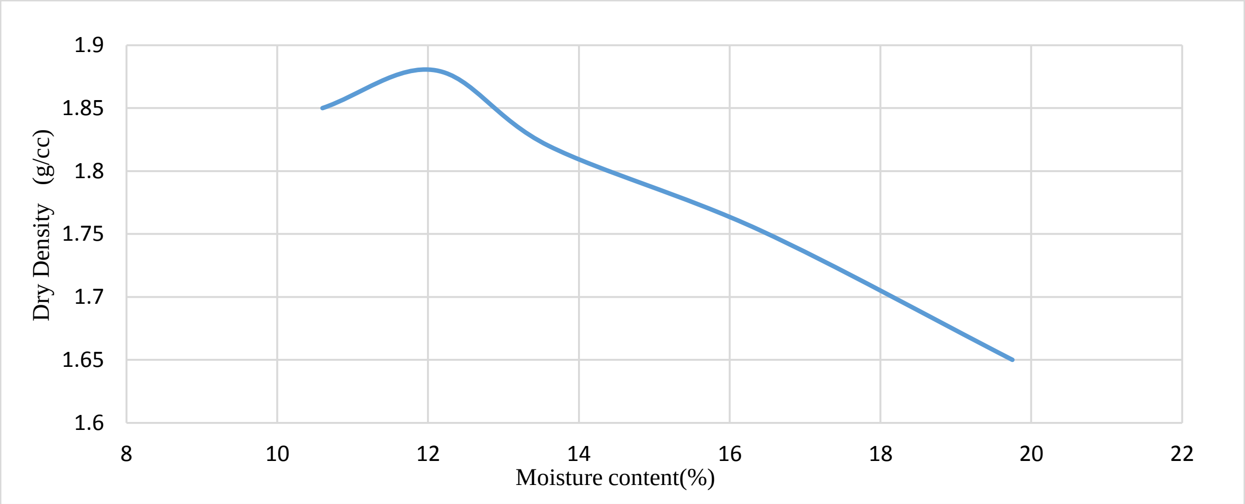

Figure 14. Moisture Vs DD Graph for Jhirpani

First the dry density increases with increase in water content. But after a certain limit it goes to its maximum dry density and start decreasing by adding further water. The water content, at which the dry density of a soil is maximum, is known as Optimum Moisture Content of the soil.

Using the graph (figure 14) the OMC is determined as 12.1 % and its corresponding dry density is 1.88 g/cc.

DETERMINATION NO.	1	2	3	4	5
Wt of mould + compacted soil(kg)	3.869	3.965	4.081	4.081	3.996
Wt of compacted soil(kg)	2.027	2.123	2.239	2.239	2.154
Wet density(g/cc)	2.027	2.123	2.239	2.239	2.154
Cruble wt(g)	12.58	12.16	12.72	12.02	12.42
Wt of cruble+wet soil(g)	32.86	44.13	45.03	41.38	57.98
Wt of cruble+dry soil(g)	31.35	40.67	41.00	37.33	49.67
Wt of water(g)	1.51	3.46	4.03	4.05	8.31
Water content (%)	8.03	12.11	14.22	16.01	22.30
Dry density(g/cc)	1.87	1.89	1.96	1.93	1.76

Table 5 Standard Compaction Test for Panposh

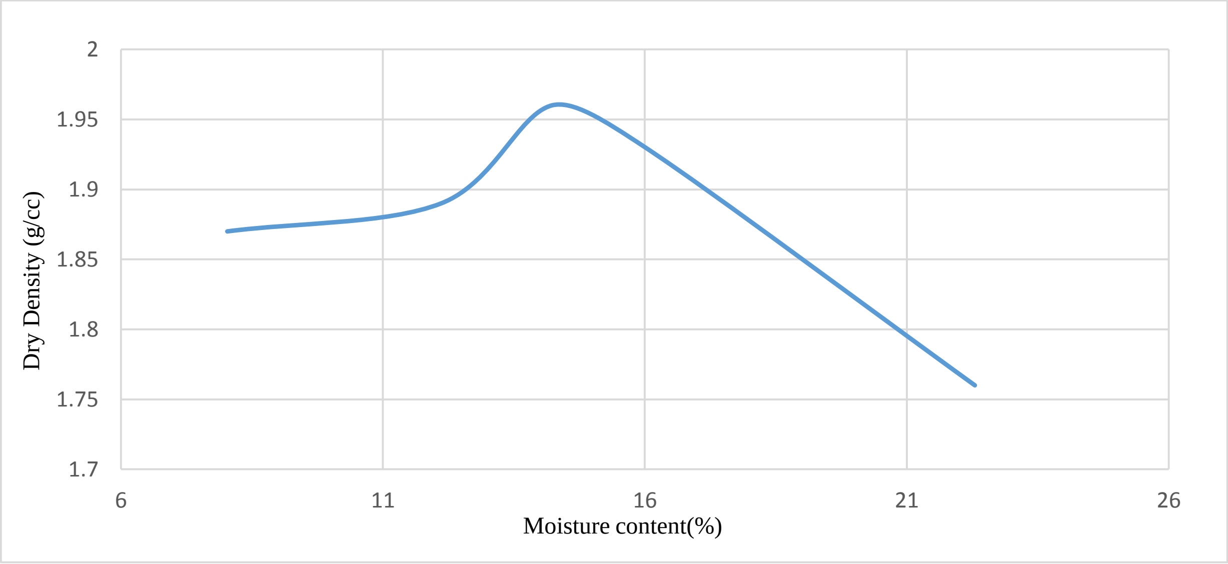

Figure 15. Moisture Vs DD Graph for Panposh

Same methods are done as explained above. Using the graph (figure 15) the OMC of Panpos Sample is determined as 14.22 % and the maximum dry density is 1.96 g/cc.

5.6 Direct Shear Test

The test is done for 4 samples. The axial load is being increased by 0.5 kg and its corresponding shear value is noted. A graph is drawn between axial load Vs shear stress and soil parameters are determined by using the equation 6. The results are shown in the table 6 and 7 and its corresponding graph is plotted, shown in figure 16 and 17 respectively.

SL NO.	NORMAL STRESS APPLIED(Kg/cm^2)	STRESS DIAL GUAGE OBS.	SHEAR FORCE(kg)	AREA $A_0(cm^2)$	SHEAR STRESS(kg/cm^2)
1	0.5	28	9.69	36	0.25
2	1.0	89	30.84	36	0.86
3	1.5	114	39.50	36	1.09
4	2.0	131	45.39	36	1.26

Table 6. Direct Shear Test for Jhirpani

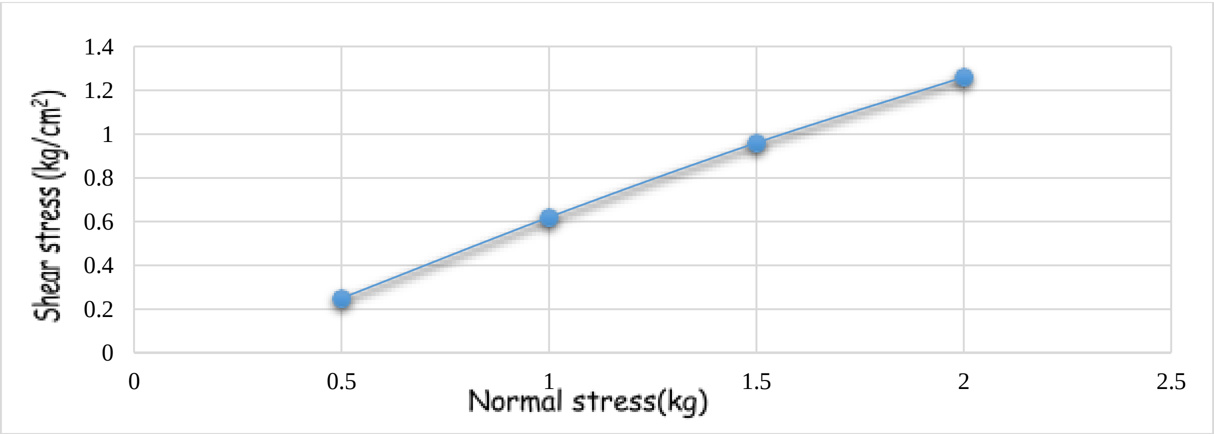

Figure 16. Normal Stress Vs Shear Stress

The graph always gives a linear equation (by equation 6). The soil cohesion c and angle of shearing resistance ϕ can be determined using the graph. At normal stress=0 the graph will show the shear stress in y-axis. This will be the cohesion of the soil and the gradient of the line will represent the angle of shearing resistance.

From the figure it can be seen that the graph will pass through the origin. Hence from equation 6 at σ=0, S=0 and hence Cohesion of the soil c=0. i.e, the soil is totally free of clay particles. The sample is found as very fine graded silty soil.

SL NO.	NORMAL STRESS APPLIED(Kg/cm^2)	STRESS DIAL GUAGE OBS.	SHEAR FORCE(kg)	AREA A_0(cm^2)	SHEAR STRESS(kg/cm^2)
1	0.5	86	25.56	36	0.71
2	1.0	146.69	43.2	36	1.2
3	1.5	207.81	61.2	36	1.7
4	2.0	259.76	76.5	36	2.125

Table 7. Direct Shear Test for Panposh

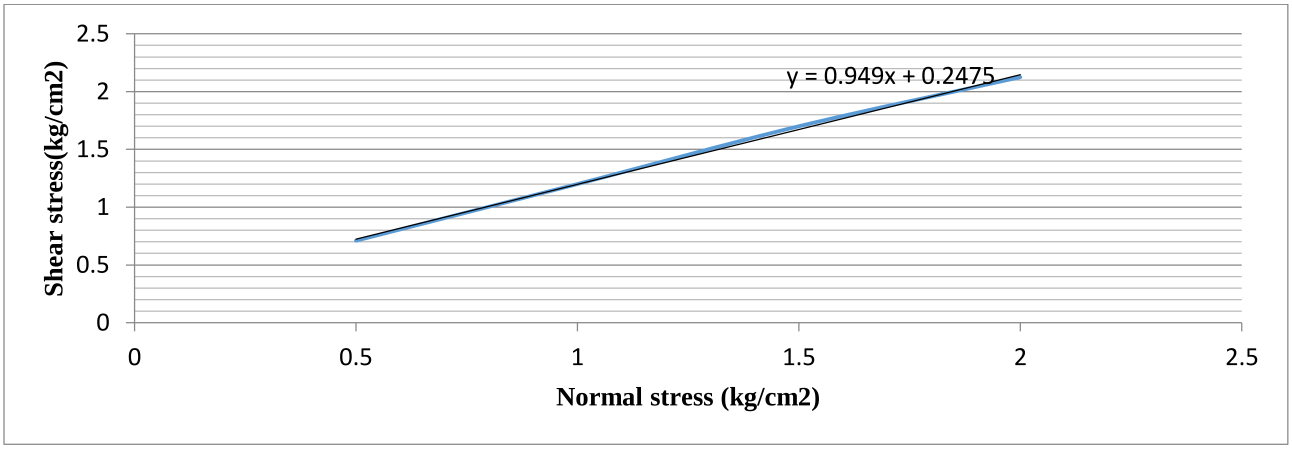

Figure 17. Normal Stress Vs Shear Stress

The equation of the line is given by

$$y = 0.949x + 0.2475$$

So, at origin i.e, x=0, y=.02475 which is represented by cohesion of the soil.

Hence c=.2475 kg/cm^2.

i.e, the soil contains small amount of clay particles.

5.7 Soil pH

The soil pH is directly determined by using pH meter, shown in figure 9.

For Jhirpani sample pH= 7.43

For Panposh Sample pH= 7.62

5.8 Heavy Metals

5.8.1 Iron

All measurement are taken from Atomic Absorption Spectroscopy (AAS). The concentration of Iron of each site is:
For Jhirpani sample, concentration of Iron = 1.837 mg/l
For Panpos sample, concentration of Iron = 1.437 mg/l

The adsorption is done by using Ordinary Portland Cement paste and the results are shown in the table 8 and 9 and its corresponding graphs are drawn in figure 18.

Time (hrs)	Concentration of Iron(mg/l)	Percentage Removal (%)
0	1.837	0
1	1.342	26.95
2	1.323	27.98
3	1.214	33.91
4	1.197	33.84
5	1.172	36.20
6	1.122	38.92
7	1.116	39.25
8	1.022	44.36

Table 8. Concentration and % removal w.r.t to time for Jhirpani

Time (hrs)	Concentration(mg/l)	Percentage Removal (%)
0	1.437	0.00
1	1.044	27.35
2	1.002	30.27
3	0.944	34.31
4	0.882	38.62
5	0.823	42.73
6	0.794	44.89
7	0.753	47.60
8	0.711	49.48

Table 9. Concentration and % removal w.r.t to time for Panposh

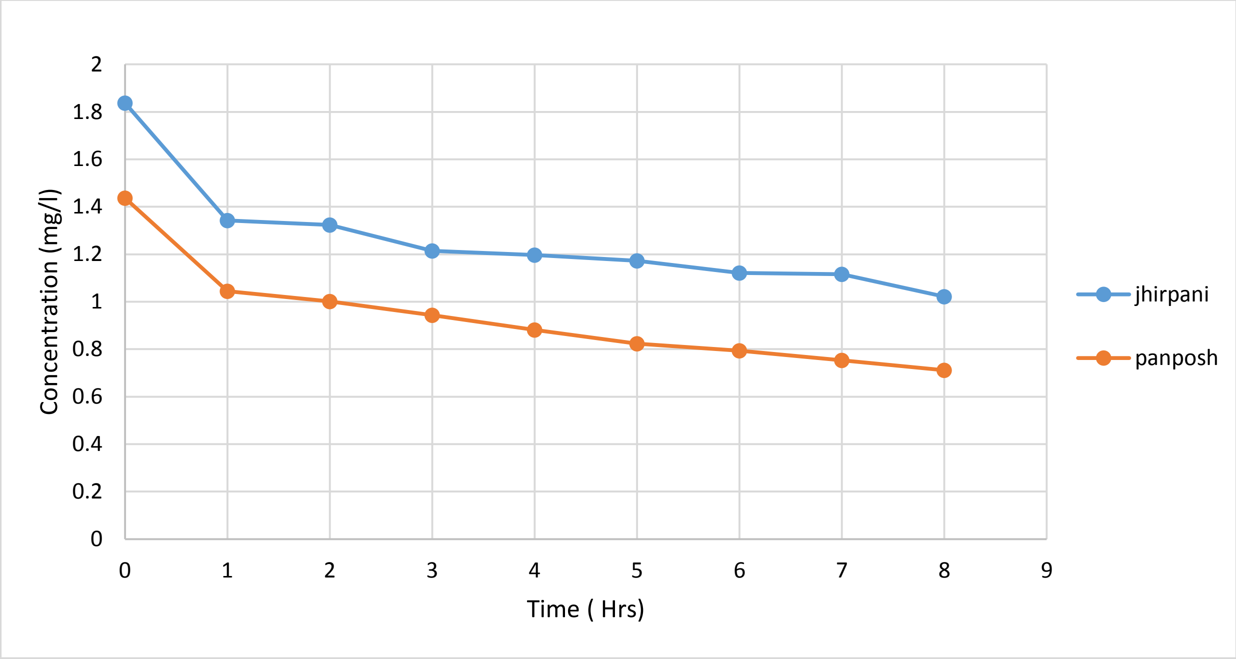

Figure 18. Time Vs Concentration for Iron

It can be seen that adsorption of Iron takes maximum within 1 hour. After that adsorption is slightly increase with time. After 8 hours, it is considered as maximum adsorption condition and the efficiency is determined by taking of its concentration. Efficiency is determined by using equation 7.

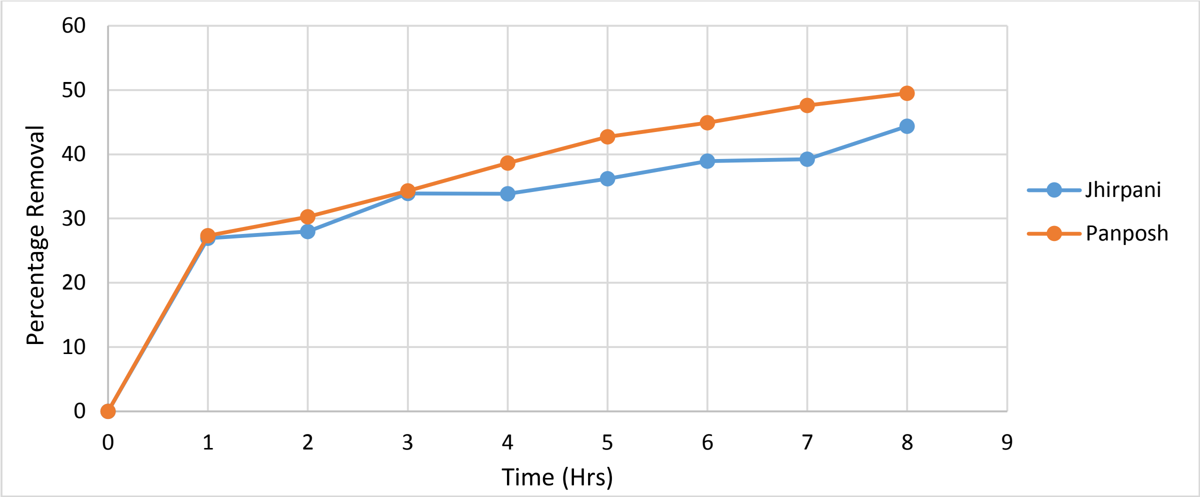

Figure 19. Time Vs Percentage Removal for Iron

After 8 hours the percentage removal of iron is 44.36 % for Jhirpani and 49.48 % for Panposh. This change of percentage removal is due to the pH differences of these two samples. Hence, for better efficiency of removal large quantity of adsorbent must be used.

5.8.2 Arsenic

For Jhirpani sample, concentration of Arsenic = 30.94 µg/l
For Panpos sample, concentration of Arsenic = 18.73 µg/l
The adsorption is done using the same adsorbent because OPC is very good Adsorber of Arsenic. The readings are taken and shown in the table 10 and 11 and the corresponding time vs concentration and time vs percentage removal of graph are plotted.

Hours	Concentration(µg/l)	Removal (%)
0	30.940	0
1	20.226	34.63
2	15.355	50.37
3	13.452	56.52
4	12.007	61.19
5	11.632	62.40
6	10.877	64.84
7	7.998	74.14
8	7.982	74.20

Table 10. Concentration of Arsenic for Jhirpani

Time (Hrs)	Concentration (µg/l)	Removal (%)
0	18.73	0.00
1	11.32	39.56
2	10.33	44.84
3	9.65	48.48
4	9.22	49.23
5	8.44	54.94
6	6.93	63.00
7	4.71	74.85
8	2.706	85.55

Table 11. Concentration of Arsenic for Panposh

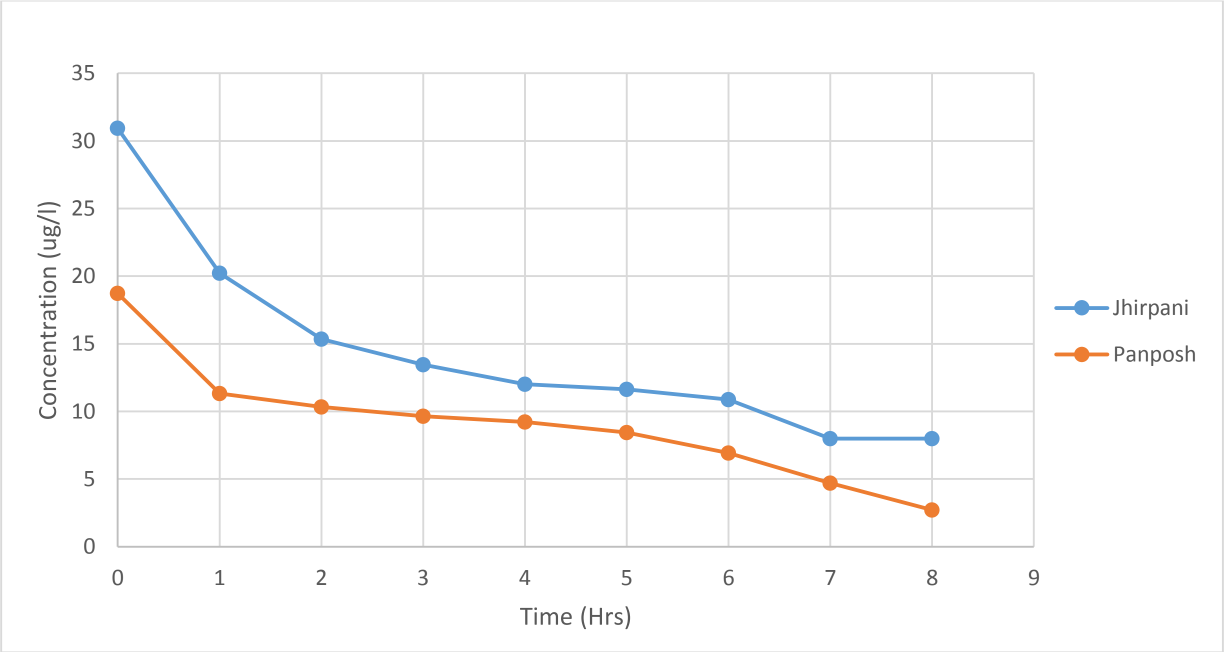

Figure 20. Time Vs concentration for Arsenic

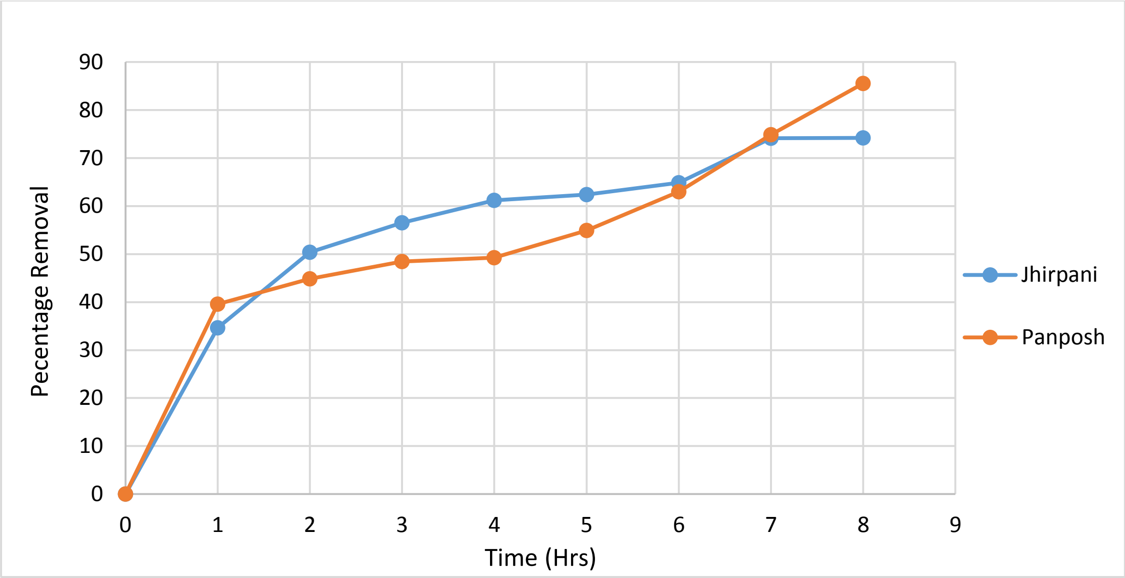

Table 21. Time Vs Percentage Removal of Arsenic

It can be seen that percentage removal of arsenic for jhirpani is 74.20 % and for panposh is 85.55 %. This difference is due to the pH differences of this soil. Also OPC has very good capacity to adsorb Arsenic.

CHAPTER - 8

CONCLUSIONS

The distance between Jhirpani and Panposh is around 18 kilometers by river. Still there are many differences in their bed sediment parameters both in physical and chemical. It can be seen that at Jhirpani the bed sediment was totally fine graded silt soil but at Panposh site it contains small amount of clay particles. Hence, additional particles make these differences in physical properties of bed sediment for same river in small distances.

There are many methods for removal of heavy metals. Adsorption is one of the cheapest method that can be done anywhere. Hardened Paste of Ordinary Portland cement has been used. Using this, many metals can be removed. Iron and Arsenic are the common heavy metals and it can be removed using hardened paste of OPC.

There is a difference between final percentage removal of Iron and Arsenic for the two sites. This is due to the pH differences. Hence, for different pH the adsorption efficiency will be different. The pH value, at which the adsorption is maximum, is known as the Optimum pH of the soil.

CHAPTER - 9

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