Water Quality Improvement Using Different Low Cost Filter materials

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By Chitaranjan Dalai

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А

DISSERTATION

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> > BY

CHITARANJAN DALAI UNDER THE SUPERVISION OF DR. RAMAKAR JHA



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### CERTIFICATE

This is to certify that the thesis entitled "Water Quality Improvement Using Different Filter materials", being submitted by Sri Chitaranjan Dalai to the National Institute of Technology Rourkela, for the award of the Degree of Master of Technology of Philosophy is a record of bona fide research work carried out by him under my supervision and guidance. The thesis is, in my opinion, worthy of consideration for the award of the Degree of Master of Technology of Philosophy in accordance with the regulations of the Institute. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any Degree or Diploma.

The assistance received during the course of this investigation has been duly acknowledged.

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This work is dedicated to the memories of those engineers and scientists, who have enhanced our knowledge on water resources and hydrologists.

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#### NOMENCALTURE

- Effective Particle Size (Particle Size at 30% finer)  $D_{10}$ = D<sub>30</sub> Particle Sizes at 30 % finer = D<sub>60</sub> Mean Particle size (Particle Size at 60% finer) = Coefficient of Uniformity Cu = Cc Coefficient of Curvature = Gs Specific Gravity = Consistency Index IC = Toughness Index  $I_{T}$ =
- $I_L$  = Liquidity index (or Water Plasticity Ratio)

#### $I_P$ = Plasticity Index

 $I_F$  = Flow Index

#### LIST OF NOTATIONS

- cm = Centimeter gm = Gram m = Meter
- mm = Millimeter
- % = Percentage
- ppm = Parts per million

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#### ABSTRACT

Water is one amongst prime elements accountable for life on the planet. India's surface water flows through fourteen major streams. Due to the importance of water, the pattern of human settlement throughout history has usually been determined by its convenience. The wealthy stream valley with copious water represents the beginning of refinement. The demand for water has increased dramatically with growth and its use turned out to be much more varied. At present, there is a growing awareness of the impact of contaminant on groundwater, rivers, and lakes. The climate change has affected the precipitation and the quantity of water available. Whereas, increasing pollutant loads from point and non-point sources deteriorated the quality of surface as well as ground water resources. Surface water pollution by chemical, physical, microorganism and biological contaminants are often considered as an epidemic problem.

The current study is geared toward development of affordable technology for the removal of iron and manganese from ground water in Odisha, India. The study was carried out in two parts: (a) In the first part, Soil columns with variable depths of 10, 20, 30, 40, and 50 cm at laboratory scales were used to study the rate of infiltration and obtain the most suitable depth of soil column satisfying the Horton's equation to get infiltration rate constant. Four types of soil collected from the banks of Rivers Brahmani, Koel, Sankha and Budhabalanga and having different physical properties (effective size =0.20 to 0.30 mm, uniformity constant =3.5 to 15, depth of sand = 50 cm and filtration rate = 1.05-1.25 m3/m2/hr). (b) In the second part, water quality improvement tests were carried out to remove iron and manganese concentrations using the soil column of 50 cm satisfying Horton's equation and activated carbon made from rice husk, wood, and Sugarcane

baggase. In addition to that, Zeolite chemical was also used to remove iron and manganese. Solutions of very high concentrations of iron and manganese were prepared in the laboratory and to remove the iron and manganese, the most effective locations, amount and type of activate carbon in the soil column and the type of soil obtained from different river locations having most appropriate physical properties were analyzed. It has been observed that 100% iron is removed from activated carbon with significant amount of rate of flow. The only maintenance needed was periodic washing of the filter or replacement of the filter materials.

The developed filter media with water purification technology can be utilized as river bank filter material to remove the pollutants from water directly being extracted by groundwater pumping for water supply to the towns in addition to natural filters. Further, this technique would help to remove the pollutants from rain water harvesting process, surface water and ground water stored in the over head storage tanks having sufficient head to pass through 0.1-0.01 micron size activated carbon prepared from different materials.

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### **CHAPTER 1**

### **INTRODUCTION**

#### INTRODUCTION

#### 1.1 General

The planet is facing formidable challenges in meeting rising demands of unpolluted water due to (i) extended droughts, (ii) increased population, (iii) additional demand for health-based rules, and (iv) competitive demands from a range of users (Savage and Diallo 2005) With simply three percentage of all available water on the planet being fresh water, seawater is the most abundant available source of drinking water and water for industrial usage in several regions. Innovations within the development of novel technologies to desalinize water are among the most exciting and promising style of users (Chartres et al., 2006).

Water treatment experimentation these days in the main focuses on disinfection by products. Commonly used chemicals for the various treatments are synthetic organic and inorganic substances. In many places these are expensive and they have to be imported in hard currency. Many chemicals are also associated with human health and environmental problems (Crapper et al.1973; Christopher et al. 1995; Kaggwa, 2001; Kebreab, 2004) and a many of them have been regulated for use in water treatment. Natural materials can minimize significantly reduce treatment cost if available locally.

The scale of the matter of water quality is even larger. It's clearer that several of the existing improved sources in developing countries don't offer water of adequate quality for domestic functions. A well accepted example of this is the extensive contamination of tube wells with naturally occurring arsenic in Asia. As serious as this and different Cases of chemical

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contamination are, the principal cause of concern is microbiological contamination, especially from faeces. While groundwater is generally of much higher microbiological quality than surface water is generally number of sources and systems used by people for drinking and cooking water aren't adequately protected against dirty contamination. This is often as a variety of factors, including population pressure, urbanization and also the inadequate construction, operation and maintenance of water systems.

Even totally protected sources and well managed system do not guarantee that safe water is delivered to households. The majority of the world's people don't have reliable unit water connections and many of those should still physically carry water and store it in their homes. Studies show that even water collected from safe sources is likely to become faecally contaminated throughout transportation and storage. Safe sources are necessary; however it's only with improved hygiene, higher water storage and handling, improved sanitation and in some cases, household water treatment, that the quality of water consumed by people can be assured. An increasing body of evidence is showing that water quality interventions have a larger impact on diarrhea incidence than previously thought, particularly when interventions are applied at the Household level (or purpose of use) and combined with improved water handling and storage (Fewtrell et al, 2005; Clasen et al, 2007).

The presence of heavy metals in the environment is another major problem due to their toxicity to many life forms. Its treatment using precipitation is not always able to meet the metal influx standards. Technologies namely reverse osmosis, while able to meet the standards, are very expensive. The innovative technologies that are cost-effective and are able to reduce heavy metal concentration to low levels are essentially needed in the developing countries (Abdo, 2002).

Activated carbon (AC) is established as most popular and widely used adsorbent in water and wastewater treatment throughout the world (Hassler, 1974; Perrich, 1981; Marsh and Reinoso, 2005; Bansal and Goel, 2005; Bandosz, 2006). The activated carbon, Charcol, is very old adsorbent for water purification. In the year 1973, Scheele discovered the specific adsorptive properties of charcoal for first time to treat gases followed by decolorizing of solutions in 1786 and he provided the first systematic account of the adsorptive power of charcoal in the liquid phase (Sontheimer et al., 1988). In the following years, Lowitz established the use of charcoal for the removal of bad taste and odors from water during 1789 to 1790. The credit to develop commercial activated carbon goes to a Swedish chemist von Ostreijko who obtained two patents, in 1900 and 1901, on covering the basic concepts of chemical and thermal (or physical) activation of carbon, with metal chlorides and with carbon dioxide and steam. respectively (Sontheimer et al., 1988). The process of chemical activation of sawdust with zinc chloride was carried out for the first time in an Austrian plant at Aussing in 1914 on an industrial scale, and also in the dye plant of Bayer in 1915 (Dabrowski,2001). In this type of activation, pyrolytical heating of the carbonaceous material was performed in the presence of dehydrating chemicals such as, zinc chloride or phosphoric acid (Purcell, 2006).

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Activated carbon is a typical term used to describe carbon based materials which well generally created internal pore structure. Activated Carbon is produced from a variety of carbonaceous rich materials such as wood, coal, lignite and coconut shell (Hassler et al., 1980). The high surface region, expansive porosity, well created internal pore structure (micro, meso and macropores) as well as a wide range of function display on the surface of Activated Carbon make it an adaptable material which has various applications in numerous Zones, however primarily in the natural field.

Oxygen, hydrogen, sulfur and nitrogen are by and large present in Activated Carbon as functional groups and atoms chemically bonded to the structure. The exceptional adsorption properties of carbon structure, the main functional groups which, in general, are considered to be responsible for uptake of pollutants. The unique adsorption properties of Activated Carbon can be significantly influenced by these functional groups. The functional groups on carbon surface mainly derived from activation process, precursor(s), thermal treatment and post chemical treatment. The nature and concentration of surface Practical gathering may be adjusted by suitable thermal or chemical treatments to enhance the execution of Activated Carbon for Particular contaminants evacuation.

The efficiency of ACs as adsorbents for diverse types of pollutants is well reported (Hassler and Cheremisinoff, 1980; Yang, 2003). It is well known that activated carbon has been found much efficient for removing organic compounds than metals and other inorganic pollutants. Deliberations are progressing to substantially improve the potential of carbon surface by

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utilizing distinctive chemicals or suitable treatment methods (Monser and Adhoum, 2002) which will

enable AC to enhance its potential for the removal of specific contaminants from aqueous phase. The physical and chemical structure of carbon could be changed by various methods, i.e. activation conditions (different agents, temperature and time of the process), precursor, additives, etc. (Pietrowsk et al., 2012). Different methods have been reported in the literature (Lee et al., 2006; Yin et al., 2007; Rivera-Utrilla et al., 2011; Shafeeyan et al., 2010; Dias et al., 2007) to modify AC surface which throw some light on the chemistry and mechanism behind treatment methods that enable AC surface for higher uptake of specific pollutants. General in all, the surface adjustment of AC is completed after the activation step. The alteration could be characterized into three categories: (i) chemical adjustment, (ii) physical change and, (iii) biological alteration, Furthermore, oxidative (Santiago et al., 2007) and non-oxidative (Sato et al., 2005) methods of surface treatments of AC have been reported in the literature. In previous studies, the presence of complexing groups on AC surface such as, carboxylic, lactonic, and phenolic groups have been widely examined (Snoevink and Weber, 1967; Ucer et al., 2006). Before performing any modification to AC, it is imperative to understand different Variables which impact the adsorption capability of AC. It will help to tailor their particular physical and chemical quality to enhance its affinities towards different pollutants display in aqueous solution.

In India Rice husk and Sugarcane baggase, an undesirable agriculture mass residue, are the by product of the rice milling and sugarcane industries respectively. They are one of the most important agricultural residues in quantity. Rice husk represents about 20% of the whole rice produced, on weight basis of the whole rice (Daifullah et al., 2003) whereas sugarcane baggase is

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Groundwater pumping near rivers is used in water resources management to build both water quantity and quality. River infiltration adequately recharges the groundwater extracted for drinking water purposes, and riverbank filtration (RBF) naturally improves the quality of through a variety of physiochemical and biological processes (Schubert, 2006b). Instead of constructing conventional water quality treatment facilities (e.g., coagulation/flocculation/sand filters, microfiltration), many municipalities have investigated the possibility of obtaining relatively clean potable water through the development of RBF systems (Fox and Durnford, 2003). Advantages of RBF relative to conventional treatment technologies include lower capital investments and operating costs due to lower energy requirements and reduced usage of chemicals. RBF is also used to pre-treatment of surface water of poor quality, reducing the cost of conventional water treatment and buffering fluctuations in the quality of the water entering alluvial aquifer zone (Ray, et al., 2002). Figure 1.1 illustrates the vertical profiles of saturated media and natural filtration while pumping the water from groundwater. It can be seen that the river water also contributes significantly to the pumping wells through natural filters. River bank filtration RBF systems was observed to be declined in pumping capacity due to clogging of the porous media and this is confirmed by pressure, infiltration, and sediment data analyses (Hubbs, 2006b; Schubert, 2006a).



Figure 1.1: (a) Vertical profiles near the saturated zone of the river banks, (b) water

#### purification through natural media

To remove clogging of the porous media and to enhance the rate of filtration, we may design a filter media to replace it with natural media (Figure 1.2). This concept is also useful if we use the same filter media developed to remove pollutants and maintain the rate of filtration in rainwater harvesting, surface and groundwater stored in overhead tank.



Figure 1.2: Water purification using Best filter material addition to natural filters

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#### 1.2 Research Objectives and Outline

In this present study, it is proposed to investigate completely different methodologies (especially in-situ removal, adsorption method) that are in use to remove iron and fluoride from domestic water with following objectives

- 1. To find out the rate of filtration in different types of soil and obtain most suitable soil column for obtaining the maximum rate of filtration in different soil.
- 2. To study the physical properties of different soil indicating different characteristics of natural river sites of data collection and their suitability for river bank filtration.
- 3. To develop different types of activated carbon in the laboratory using rice husk, sugarcane baggase, and wood charcoal.
- To study the water quality improvement in Iron and Fluoride using different combinations of activated carbon, Zeolite and soil columns.
- To study water quality improvement by considering the amount of activated carbon used, placement of activated carbon in soil column and rate of infiltration being maintained at outflow.
- 6. To compare the result & identify the low cost filter material suitable at different river sites.
- 7. Carry out cost-benefit analysis and management of rejects.

#### 1.3 Thesis Outline

The thesis consists of six chapters. General introduction is given in Chapter 1, literature survey is presented in Chapter 2, experimental Setup & Data collection is described in Chapter 3, Methodology are outlined are discusses in Chapter 4, Chapter 5 Results Analysis and finally the conclusions and references are presented in Chapter 6.

General view on Water & water quality is provided at a glance in the first chapter. Also the chapter introduces the concept of Treatment of water use various Researchers in early date. It gives an overview of water quality Improvement.

The detailed literature survey by many researchers that relates to the present work from the beginning till date is reported in chapter 2. The chapter emphasizes on the previous research carried out in different water treatment process various parameter conditions based on using low price filter materials.

Chapter three describes the experimental Setup & data collection as a whole. This section explains the experimental arrangements and procedure adopted to obtain observation at different Layers using filter materials. Also the detailed information about the instrument used for taking all tests observation is given.

The Methodology regarding Physical analysis, chemical analysis for river bank soil and Infiltration rate at various depth conditions and quality improve at using different filter materials are outlined in chapter four. Also this chapter discusses the technique adopted for measuring water quality.

Analyses of the experimental results are done. Incorporates the results obtained from research work and analysis done for the water conditions is presented in this Chapter five .Also

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Presents significant of different filter material use as low cost techniques this research are also

#### discussed.

Finally, chapter six summarizes the important conclusion reached by the present research and

recommendation for the further work is listed out.

References that have been made in subsequent chapters are provided at the end of the thesis.

# **CHAPTER 2**

### LITERATURE REVIEW

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#### LITERATURE REVIEW

Studies regarding the water quality analysis, Water filtration are carried out for using low cost filter materials. The filters material, which important element originated from filters system with respect to prolonged life and wear protection of the system. It is so frequent in water that it has attracted the interest of investigators from many disciplines. Since then, a lot of experimental studies have been reported, more so, in this last decade. It may be worthwhile to know the Decisive criteria for the selection are the necessary degree of cleanliness of the operating medium, the initial rate differential and the contamination retention capacity. Before knowing about the filter materials as limited studies concerning the low cost materials used water filter are available till date.

Many researchers over the globe are finding out on the water quality capabilities and performance using different techniques. Some of these recent studies are mentioned below:

- Among the earlier investigators, Catherine (1988) studied the management of biological iron removal from drinking water using oxidation-reduction potential. During this study a pilot plant was used for treating raw water with pH 5.7 for biological removal of iron to produce drinking water. Here oxidation- reduction potential was used as a tool for evaluation and determination of relationship with dissolved oxygen and residual iron concentration within the infiltrate by employing a biological filter.
- Hasan (1990) studied the contact aeration for iron removal methodology. The iron removal method utilized the catalytic impact of ferric iron. Again in this experiment it had been theoretically demonstrated that by keeping high concentration of ferric iron, the volume of

the aeration tank are often significantly reduced and it had been according to the oxygenation rate equation. Ferric iron is very much effective in decreasing the reactor volumes at lower pH values. It's projected to recycle the ferric sludge to maintain the high ferric iron concentrations within the reactor.

- William, et al. (1992) studied the impact of dissolved organic carbon on the removal of iron throughout water treatment. He used the iron removal method by oxidation and coagulation method. Humic and fulvic acids, tannic acid and oxalic acid were calculable within the organic content. Potassium permanganate, chlorine dioxide and free chlorine were used as oxidizing agent.
- Dong, et al. (1992) conducted experiments on Surface coatings were collected on glass slides within the oxic surface waters of Cayuga Lake and Hydroxylamine hydrochloride was used to selectively remove Mn oxides, sodium dithionite was used to remove Mn and Fe oxides, and 10% oxalic acid was used to remove metal oxides and organic materials. Were wont to appraise the relative contributions of Fe, Mn adsorption by the surface coating materials. The estimated Pb distribution between surface coating components with that previously predicted by an additive adsorption model based on Pb adsorption isotherms for laboratory surrogates for Mn, Fe and Al oxides and defined biological elements.
- Boller, (1993) developed a Roughing filtration technology, this filtration method through a coarse medium using low filtration rates. It's in the main used as pretreatment so as to

retain solid matter before slow filtration. This method has been used successfully as pretreatment to remove turbidity, being subsequently followed by slow sand filtration.

- Vandenabeele (1995) analysis for the influence of Nitrate superimposed to the medium on Mn removing microbial consortia from sand filters. He point out the importance of nitrate for efficient Mn removal in rapid sand filters. On the other hand, nitrate might also have an indirectly beneficial effect on the removal of Mn, by preventing Mon2, previously deposited on the sand from being reduced under microscale anoxic conditions.
- Tomotada (2001) studied this bioremediation observe and perspective. In the method he
  used in-situ fluorescence hybridization (FISH), in situ PCR, and quantitative PCR for
  removal of contamination by bioremediation .In this methodology the detection and
  reorganization of bacteria and pathogens is incredibly vivid and these are being directly
  associated with the rate of degradation of contaminants.
- Sogaard, (2001) built as a pilot plant that sand filter has purpose of biological precipitation
  of Fe form ground water polluted within the main chlorinated aliphatics. The pollution
  includes trichloroethylene and tetrachlorethylene together with smaller amounts of
  pesticides. And also observe the mechanism of Fe precipitation in an exceedingly sand
  filter within the all conditions for biotic as well as abiotic Fe mineralization in sand filters
  of fresh water treatment plants.

- Wang, et al. (2003) studied the removal of heavy metal ions from liquid solutions using various adsorbents with minimal cost. He used various low cost adsorbents like Fe2O3, Fe3O4, FeS, steel wool, Magnesium pallets, Copper pallets, Zinc pallets, Aluminum pallets, Iron pallets, coal, GAC for removal of heavy metal ions like cobalt and zinc from ground water.
- Choo, et al. studied (2005) the removal of iron and manganese in radical filtration and also the method of membrane fouling. He also examined to remove the residual chlorine due to pre-chlorination that is opted as a convenient option for safe potable water. The membrane fouling was caused due to the oxidation of iron and manganese that was also visualized thoroughly at microscopic level and also the steps for eradicating the degradation of membrane were proposed.
- Pacini, et al. (2005) conducted a series of experimental studies and tired to removal of iron and Mn from groundwater using biological roughing up flow filtration technology. The performance of roughing filter technology in a biological treatment method for the removal of iron and manganese, without the use of chemical agents and under natural pH conditions were studied. Two pilot plants, using two different natural groundwater, were operated with the subsequent treatment line: aeration, up flow roughing filtration and final filtration (either slow or rapid). This technique combines easy, affordable operation and maintenance with high iron and manganese removal efficiencies, therefore constituting a technology that is especially suited to little waterworks.

- Takerlekkopoulou, et al. (2006) studied the physio-chemical and biological iron removal from potable water. He used the technique of trickling filter and created a model for it together with the pilot-testing. The main mechanism was physio-chemical and biological oxidation of iron. The detailed chemical process and extent of every oxidation was studied. Experimentation was finished specified temperature; optimum feed iron concentration and volumetric flow rate. First order kinetics and Monod-type kinetics was observed in physio-chemical and biological oxidations respectively.
- Gupta (2006)studied the non-conventional low-cost adsorbents for dye removal. He studied
  an in depth variety of adsorbent for filtration and within the review he showed the critical
  analysis of these materials, characteristics, advantages, limitations and mechanisms of
  sorption. He used activated charcoal of agricultural solid waste, industrial by product, clay
  and materials containing silica oxide.
- Bordoloi, et al. (2007) studied the removal of iron from water using the ash created from banana residue .Ashes from different materials i.e. dry banana leaf, pseudo stem, rind, bamboo, rice husk were produced by controlled combustion. The mechanism of removal includes oxidation of iron at high pH or alkaline medium created by potassium Present in banana due to subsequent formation of potassium hydroxide. The study enclosed analysis of chemical composition of banana ash and its potency in removal of iron from ready-made water. Further it has been employed in a low cost household water purification model during which after treated with ash, the water is being filtered with a cotton cloth and being used for drinking.
- Ganvir, et al. (2011) studied the removal of fluoride from groundwater by aluminum hydroxide coated Rice husk ash. Activated aluminum hydroxide has been used for

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activating the RHA surface that forms a complex with fluoride ion in water and accelerates the method of removal.RHA was obtained by controlled burning of dry and crushed rice husk and treating with hydrochloric acid before activation.

- Chaturvedi (2012) studied the removal of iron for safe potable water. He used the methods
  of iron removal from drinking water such as electro coagulation; oxidation filtration, ion
  exchange, lime softening, adsorption by activated carbon, BIRM media, Anthracite, green
  sand, pebble and sand mixture, ultra filtration etc are mentioned.
- Simonis(2012) studied the manufacturing a affordable ceramic water filter and filter system for the elimination of common pathogenic bacteria and suspended solids. A micro-porous ceramic water filter during which clay was mixed with rice husk in a ration 2:1 by weight and a cylindrical formed filter was manufactured by tradition oven drying and then burning in kiln at specified sintering temperature. After being coated with silver nitrate solution for preventing the expansion of microbes, the filter was tested for removal of suspended solids and pathogens.

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## **CHAPTER 3**

# EXPERIMENTAL SETUP AND

**DATA COLLECTION** 

"Experience is the past tense of Experiment"

3.1 Data Collections

There is no standard procedure for obtaining soil samples. Usually the details of procedure will depend on the purpose for which the sample is taken, depending on the part of the soil profile required (surface versus subsurface), and the type of sample required (disturbed versus undisturbed). In the present work, soil samples are collected using hand auger, a series of extension rods, a "T" handle, and a thin-wall tube sampler. The auger bores a hole to a desired sampling depth and then is removed. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and forced into the ground at the completion depth. The core is then withdrawn and the samples collected. Augers are better for direct sample recovery, are fast, and provide a large volume of sample. The soil samples were collected from different river bank sites and are illustrated in Figure 3.



(1)Latitude: 22.27, Longitude: 84.90, (2) Latitude: 22.22, Longitudes: 84.80, (3) Latitude: 22.27, Longitudes: 84.93
(4) Latitude: 21.92, Longitudes: 86.72

#### Figure 3.1: Map showing four soil sampling sites at river Banks

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#### 3.2 Design and Development of Filtration Model

Normally, it is difficult to design filter media to carry out infiltration tests as well as water quality improvement tests at laboratory scale. In the present work we designed a simple cylindrical filtration fiber tube supported in a stand with the following dimension: Length = 30cm, Internal diameter = 8cm and Outer diameter = 10 cm. Base is roofed with a porous plate of 5mm diameter pores as shown in Figure 3.2. The top of the cylinder was covered with a perpex sheet of 1 inch thickness a hole of 2 cm diameter was made to connect to the inlet pipe is keyed to attach with the source of water tank stored. Continues Depth of water was maintained during these experiments.





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The equipment developed in the Department of Civil Engineering, NIT Rourkela was used to study (a) Infiltration rate of soil columns having different physical properties, and (b) water quality improvements using different filter media along with soil columns. Generally, soil in nature maintaining different physical and chemical characteristics (Figure 3.3) and to predict the rate of flow of water in different natural conditions, we need to design filtration tube (Column) and carry out several experiments. Many researchers have developed variety of models which partially satisfy natural conditions. However, no proper model has been developed so far to predict rate flow relationships with time in numerous conditions taking all necessary parameters under consideration. The equipment designed and developed gives more accurate infiltration capacity prediction for various soils and rate of water quality improvements. It consists of four major components: air, water, organic matter, and mineral matter.



Figure 3.3: Characteristics of soil (a) distribution of variables, and (b) particle size mixing

#### 3.2 Mechanical Analysis of Soil

Mechanical analysis is done to determine the particle size of the soil and its distribution expressed as the percentage of the dry weight. The soil has four constituent parts:

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- Sand particle size larger than 0.06 millimeters (0.002 inches).
- Silt particle size ranging from 0.002 0.06 millimeters.
- Clay particle size below 0.002 millimeters,
- Colloidal clay which does not settle out of suspension in water. The particle size distribution was done by two methods (Figure 3.4):

(1) Sieve analysis- for particle sizes larger than 0.075 mm in diameter, and

(2) Hydrometer analysis- for particle sizes smaller than 0.075 mm in diameter.



Figure 3.4: Particle size distribution using (a) Sieve analysis, and (b) Hydromter analysis

Once the particle size distribution was done, it is essential to carry out liquid limit and Plastic limits of the soil samples collected from various sources. Figure 3.5 shows the setup used for analyzing liquid limit and Plastic limits of the soil samples. Further, the setup used for analysis of Shrinkage limit and specific gravity is shown in Figure 3.6.

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Figure 3.5: Setup for (a) analyzing liquid limit and (b) Plastic limits of the soil samples

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(b)

Figure 3.6: (a) Shrinkage limit and (b) Specific Gravity Test setup

#### 3.3 Water quality test experiments

UV Spectro-photometer, Atomic Absorption Spectrometer and X-Ray Powder Diffraction Analysis were used for water quality tests and soil mineralogy test (Figure 3.6). Obtaining useful data from X-Ray Powder Diffraction (XRD) needs the ability to regulate and/or measure angular relations between incident and diffracted radiation. Two kinds of instruments are accustomed to perform X-ray powder diffraction analysis: the XRD powder camera and the X-ray diffractometer. The powder camera approach entails recording diffraction maxima "cones" on cylindrically mounted photographic material surrounding the specimen. The diffractometer records the intensity of the diffracted beam electronically at precise associate angles because the specimen is scanned over an angular range. Modern diffractometers have a number of advantages over the powder camera and are the more commonly used instruments in soil mineralogy.





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Figure 3.6: (a) UV Spectro-photometer, (b)Atomic Absorption Spectrometer and

(c) X-Ray Powder Diffraction Setup

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**CHAPTER 4** 

### **METHODOLOGY**

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#### 4.1 General

- 1. Various experiments were performed in order to see the characteristics of the soil samples collected from the banks of Rivers Brahmani, Koel, Sankha and Budhabalanga. First of all, the samples were analyzed for the following physical parameters by experimental analysis. Test for Grain Size Distribution
- 2. Test for Liquid Limit
- 3. Test for Plastic Limit
- 4. Test for Shrinkage Limit
- 5. Test for Specific Gravity
- 6. Test for Moisture Content
- 7. Thereafter, the following chemical analysis was done.
- 8. Test for Alkalinity i.e. pH Test
- 9. Test for Iron and Fluoride Content

#### 4.2 Grain Size Distribution test

Soil is a porous mass consisting of aggregates of particles of different shapes and sizes held together by inter particulate electro chemical forces as shown in Figure 3.2. Thus the variation in size of particles of the grains in a soil mass can form one of the basis of classification of soils. Though grain size particles distribution in soil is not adequate to predict grained mass, it provides information for classifying the soil into coarse or fine grained groups. Coarse grained soil can be further classified into two sub groups. The results of grain size analysis are used in soil classification design of filters for earth dams, determination of suitability of soils for earthen embankments and road construction. Soil Page 45

fraction coarser than 0.075mm size is fraction or fines. Particles having sizes more than 4.75mm is gravel, particle sizes between 4.75mm and 0.075mm is sand particle sizes in between 0.075mm and 0.002mm is silt and particle sizes finer than 0.002mmis clay. Grain size analysis is normally done in two stages. For coarse grained fraction, sieve analysis is used and for fines the pipette/hydrometer analysis is used. When the fines are not greater than 10% sieve analysis alone would suffice. Sieve analysis is more direct method where the (equivalent) grain size refers to the sizes of the sieve opening.

#### 4.2.1 Procedure

- Air dry the soil samples after pulverizing it. Pulverization is done only to break the soil lumps and clods, but not to split an individual soil particle. Take about 300gm. of representative soil by sample splitters and dry it in oven.

- Weigh the oven dry soil and wash it with water thoroughly.
- Clean the sieves with proper brushes. Note their sizes and take their (empty) weights.
- Arrange the sieves vertically such that each sieve is fine than the one above and coarser than the one below. Place collecting pan under the finest sieve.

- Place the entire assembly of sieves on the sieve shaker and shake for 10 mins.

-Weigh each of the sieves along with the soil retained on it. Check that the sum of the weights of the soil samples retained on all the sieves (including the pan) is equal the total weight of the soil taken for the sieve analysis.

- Calculate the cumulative percentage of soil retained on each sieve on the basis of the total soil taken for the grain size analysis.

#### 4.3 Liquid Limit Test

Liquid limit is the water content corresponding to the boundary between liquid and plastic states of consistency of soil mass. The liquid limit and plastic limit of soils are both dependent on the amount and type of clay in soil and form the basis for the soil classification system for cohesive soils based on plasticity test. It also gives the cohesion property of soil and the amount of capillary water which it can hold. Consistency Index (I<sub>C</sub>): Ratio of the liquid limit minus the natural water content to the plasticity index of the soil. Flow Index (I<sub>F</sub>): The slope of the flow curve obtained from a liquid limit test, expressed as a difference in water content at 10 blows and 100 blows. Liquidity index (or Water Plasticity Ratio) (I<sub>L</sub>): The ratio expressed as a percentage of

natural water content of soil minus the plastic limit to its plasticity index. Plasticity Index (I<sub>P</sub>): The Numerical difference between the liquid limit and plastic limit.

Toughness Index (I<sub>T</sub>): The ratio of plasticity index to the flow index.

#### 4.3.1 Procedure

- Weight about 200 gms of air dried soil passing through 425 micron I.S. Sieve.

- Take the soil in a porcelain basin and add clear water till it becomes paste. Mix the soil thoroughly (certain soil require mixing up to 40 minutes).

- Check and adjust the fall of the liquid limit device cup to exactly 1 cm , using the gauge on the handle of the grooving device.

- Place the soil paste in the cup of liquid limit device and level it horizontal with lowest edge

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of the cup, with spatula so that the maximum depth of soil in the cup is 1 cm.

- Using standard grooving tool, make a groove in the middle of the soil along the diameter, dividing the soil into two parts (use Casagrande's grooving tool for soils containing more clay and ASTM for soils containing more silts).

- Turn the handle of the liquid limit device at the rate of 2 revolutions per second, till the two parts of the soil in the cup join together i.e. the groove closes by 12.0 mm length. Ensure that the grooving closes by flow and not by slipping of soil on the surface of the cup.

- Note the number of blows imparted to the cup. Taken about 10 grams of moist soil from the centre of the groove in a moisture tin and determine its moisture content.

- By altering (increasing) the water content of the soil and repeating the above operation obtained five or six sets of observation, for blows in the range of 15 to 35.

- The test should always proceed from drier (more blows) to wetter (less blows) condition of the soil. Each time the soil is thoroughly mixed to ensure that the water content is uniform throughout the soil mix.

- Note the number of blows imparted to the cup. Taken about 10 grams of moist soil from the centre of the groove in a moisture tin and determine its moisture content.

#### 4.4 Plastic Limit test

Plastic limit is the water content corresponding to the boundary between plastic and semi-solid states of soil mass. It the water content at which a soil, when rolled into a thread of 3 mm. diameter just begins to crumble.

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#### 4.4.1 Procedure

- Take about 20 grams of air dried soil passing through 425 micron I.S. Sieve

- Place the soil in a porcelain basin and mix with sufficient quantity of water until the mass becomes plastic enough to be easily moulded with finger

- Take a portion of the wet soil and form it into a ball and roll it quickly on a glass plate with the palm of hand into a thread of uniform diameter. If the soil cannot be rolled into thread at all or even if the thread on first rolling breaks before reaching a diameter of 3 mm, the initial trial water content is less than plastic limit of the soil. Hence add a little more water to make it more plastic. Continue the process and rolling till the threads reach a diameter of 3mm. The rate of rolling should be 80 to 90 strokes per minute.

- If the soil does not crumbles at a diameter of 3mm, you need the soil and make ball out of it and reroll it again till it begins to crumble at 3mm diameter.

- Take some crumbled soil pieces and determine its water content.

- Repeat the experiment at least three times and the average water content is recorded as the plastic limit of the soil.

#### 4.5 Shrinkage Limit test

The maximum water content at which a reduction in water content will not cause a decrease in volume of soil mass is defined as the shrinkage limit. For clayey soils the lower the shrinkage limit the more will be degree of shrinkage and expansive clays. Its concept is useful in identifying expansive clays. It may be termed as the water content when the soil changes from a semi solid state to solid state of consistency.

#### 4.5.1 Procedure

- Take about 50gms of soil passing through 425 micron sieve into a porcelain dish and mix the soil thoroughly with sufficient quantity of water to such a consistency that the soil may flow(i.e. water content close to the liquid limit or slightly higher).

- Coat the inside of the shrinkage dish with a thin layer of Vaseline/grease to prevent the adhesion of the soil to the dish.

- Fill the soil paste in to the dish in a three equal quantities. After placing one-third quantity of soil paste each time, tap the dish on a firm surface cushioned by several layers of blotting paper or rubber pad until the paste is thoroughly compacted and all entrapped air comes out to the surface in the form of bubbles. Repeat the same operation for next two layers strike off the excess soil paste with a straight edge and wipe off all soil adhering to the side of the dish.

- Take the weight of the dish with wet soil (w1). Allow the soil to dry off in air till the colour of the pat changes from dark to light. Then put the dish in oven at  $105^{\circ}$  c  $-110^{\circ}$  c for 24 hours.

- Weight the shrinkage disk with dry soil pat (w2) and also weight the empty dish (w3).

- Fill the empty shrinkage dish completed with mercury. Remove the excess mercury by pressing a plane glass plate over it. Find the weight of mercury ( $_{Wlk}$ ) filling the dish. The volume of cup can be found out by dividing this weight by 13.6, this volume is equal to volume of wet soil ( $_{V1}$ ).

- Place a glass cup full of mercury in a porcelain dish. Press a glass plate with three metal prongs, over the cup removing the excess mercury into the porcelain dish. Carefully remove the glass plate and weight the glass cup full of mercury, now remaining (w6 gms.).

- Again place the glass cup in the porcelain dish & keep the dry soil pat over the mercury in the glass cup. Place the dry soil pat into the glass cup using the same glass plate. In this

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process the dry soil pat get submerged in the mercury causing excess mercury to escape into the porcelain dish. After ensuring that the glass cup and that no further mercury tends to escape, carefully remove the glass plate and the soil pat and take the weight of glass cup (w7)

gms.

- The weight of mercury displaced by the dry soil pat is equal to w5 gms. , (w5=w6-w7) and the volume of dry soil pat (v2 = w5/13.6) c.c.

#### 4.6 Specific Gravity tests

The specific gravity is the ratio of weight of a given volume of dry soil particles in the air to the weight of equal volume of distilled water at a temperature of  $4^0$  C. The specific gravity of the soil particles is useful mainly for deriving other properties of soils like void ratio, grain size distribution & identification of minerals to some extent. For sand grains the average value of specific gravity is about 2.65 and for clay particles it varies from 2.5 to 2.9 with a statistical average of about 2.7.

#### 4.6.1 Procedure

- Complete volumetric flask shall be dried at 105 to  $110^{\circ}$  C, cooled in the desiccators & weight to the nearest 0.001g (W1).

- Take about 50gm of over dried soil into the Pycnometer and find the weight of Pycnometer with soil correctly (W2).

Add sufficient water up to about half the capacity of Pycnometer to cover the soil.
Shake the Pycnometer well and connect it to vacuum pump to remove the entrapped air. The pressure shall be gradually reduced to 20mm Hg and the Pycnometer is kept in that pressure for about 15 minutes.

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- Make sure that all the entrapped air has been expelled out and then disconnect the pump & fill the Pycnometer.
- Heat the Pycnometer, half filled with water and soil in a water bath or sand bath. During Heating rotate the Pycnometer facilitating the entrapped air to be escaped out easily.
- Cool down the Pycnometer to room temperature by keeping it in open air. Then fill it up completely with distilled water.
- Mark the cap and the Pycnometer with a vertical line parallel to the axis of Pycnometer so that
- each time the cap is screwed to the same extent with reference to the vertical line as guide.
- Wipe out the surface of Pycnometer by cotton & blotting paper & find out its weight (W3). Note also the temperature of the Pycnometer.
- Throw out the content of Pycnometer& wash it thoroughly.
- Fill the Pycnometer completely with water and screw on the cap as before.
- Wipe off any excess water on the outer surface of the Pycnometer& find out its weight (W4).

- Repeat the same procedure to get at least three sets of reading. Report the specific gravity of the soil corresponding to slandered temperature of  $27^{0}$  C.

#### 4.7pH Test

The pH value of the soil sample is the logarithm of the reciprocal of hydrogen ions activity present in moles per liter. For neutral sample, it is generally found to be around 7. If it is less than 7, the sample is considered to be acidic and for the opposite case, it is taken as basic. For general water, ph ranges between 6 to 8.

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#### 4.7.1 Procedure:

- The pH value of a given water sample can be measured directly using a pH meter.
- A beaker or glass in association with a calomel electrode is dipped into the water and it detects the concentration of Hydrogen ion.
- The meter is pre calibrated by using standard solution of known pH values and can be used directly to read the value.

#### 4.8 Iron content test

Iron in water exists as ferrite and ferric ions. Iron is very exceptionally critical for a healthy body and the deficiency of this nutrient result in anaemia. Higher concentration of iron in water can cause staining of fondry and porcelain when used in industry. The iron content of surface water seldom reaches 1mg/liter.

#### 4.8.1 Procedure

- Four volumetric flasks are chosen and cleaned thoroughly.
- 100ml of distilled water is taken in each of them.
- Fe solution was mixed to make 1,2,3,4 ppm solutions in the samples.
- These samples were tested in the absorption spectrometer to get the plot of absorbance concentration.
- With the assistance of the graph acquired from the above step, the river water sample was tested and directly it gave the concentration of iron in the sample.

### 4.9 XRD Analysis

X-ray diffraction is a technique that provides detailed information about the atomic structure of crystalline path. It is a compelling tool in the identification of minerals in rocks and soil. The mass of the clay fraction of many soil is crystalline, but stiff corpuscle are excessively little for optical Crystallographic techniques to be applied. Therefore, XRD has long been a backbone in the identification of clay measured minerals in soil. However, its usefulness extends to coarser soil fractions as well.



#### Figure 4.1: Schematic representation of the parts of an X-ray diffractometer.

#### 4.9.1 Procedure

- The remains saved from the centrifuge Power Spectral Density (PSD) routine has had calcium carbonate and organic matter removed. For larger counts per second and better peak recognition, branding iron should be removed. Use the chemical bath deposition (CBD) iron removal procedure after assiduousness of Henry Clay is determined, if desired. Determine the concentration of the the Great Compromiser suspension by pipetting 1-cubic centimeter of the National Institute Of Technology Rearches -500080, Oddata UtherMonth Statementscherer, after Page 54

liquid into a tared crucible, evaporate to dispassion overnight, and weigh the clay in the aliquot. Using the equating g X milliliter = g X mL, calculate the amount of clay suspension needed for pipetting to obtain 50 milligram of clay. You will need enough clay to brand three coast. Example: 0.1557 g X 1 -mL = 0.05 g X (x) mol. (x) gives the mL to pipette for one slide. Proceed to the iron removal procedure.

- Pipette double the computed corpse interruption into three 15 mL glass tubes using an electronic pipette. Setup the three handling needed for X-ray at the same time: magnesium-saturated, breeze -dried; magnesium-saturated, glycerol solvated; and potassium-saturated, air-dried. Use different colored person tape to distinguish the three different treatments.

- Using the Table 4.1 below, MBD quartet -milliliter of the solution needed at each stair to the 15-cubic centimeter glass subway system (s), vortex (mix), balance tube sets, centrifuge for 5 minutes at 1200 rpm, and decant (pour-off) supernant.

#### Table 4.1: determining peaks for mineral

Steps	Mg-sat. air-dried	Mg-sat., glycerol solvated	K-sat.air-dried
(1)	MgCl <sub>2</sub>	MgCl <sub>2</sub>	KCl
(2)	MgCl <sub>2</sub>	MgCl <sub>2</sub>	KCl
(3)	MgCl <sub>2</sub>	MgCl <sub>2</sub>	KCl
(4)	MgOAC	MgOAC	KCl
(5)	ethanol	ethanol	50% methanol
(6)	ethanol	ethanol	95% methanol
(7)	ethanol	ethanol	95% methanol
(8)	ethanol	1% glycerol- ethanol	triple distilled- water

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- Test a helping of the decanted resolution after step 7 until it gives a negative (no white precipitate) trial run for chloride with AgNO3 (silver nitrate).

- Clean microscope slide(s) with Ajax, soapy-hot water supply, and rinse with TDW. Dry the slides by standing slides on a paper towel and resting on the pan wall in a 105 ° C oven for 10 minutes.

- Stir sampling with an automatic swirl stirrer and pipette using an electronic pipette ace mL of desired treatment and berth the solution in the center of attention of a clean lantern coast labeled on the back. Let slide(s) dry overnight undisturbed. When dry, place slide(s) in a vacuum desiccator until streamlet XRD approach pattern on the Siemens D5000 Diffraktometer. Make sure there is at least a ace /4" border on the slide without stiff cloth by cleaning with a Kim wipe or towel so contaminant will not take place when the slide is placed in the holder of the XRD whole

- See the detailed instructions for operation of the Siemens D5000 Diffractometer instrument.

- Use file name for sample distribution s that denote the intervention as well as sample identification. Make a hard copy of the XRD raw pattern for reporting and interpretation as well as converting each raw file into a UXD format that can be imported into Excel so diffractogram copy with multiple patterns showing all the treatments on one varlet can be graphed (see detailed instructions for operation of the Siemens D5000 Diffraktometer). If the potassium saturated, air-dry pattern contains a 6.20 and/or octet .80 20 (14.2 or seven Å; 1.4 or 0.7 nm) peak, the slide will need to be heated to determine the minerals present.

- Take the slide(s) prepared for K-saturated, air-dried discourse after the XRD radiation diagram have been completed and station on a smooth warmth resistant sheet or place directly

the

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on

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holder in muffle furnace . Put slide(s) in order or recording label with a heat resistant pen/pencil, otherwise, the high temperature will remove labels. Place heat resistant sheet and slides into muffle. Close the muffle and turn the temperature dial to 500 0C. Estrus slides at 500 0C for II -1/2 hours. Crook the briny switch for muffle off and crack furnace room access using a wire gauze bandage or leave in the muffle until sang-froid. Remove slides and cool the residuum of the way in a desiccators until XRD can be done. -Interpret the XRD for clay minerals using tables provided.

#### 4.10 Infiltration tests

Infiltration "is the volume of water passing into the soil per unit of area per unit of time and has the dimensions of velocity." The term infiltration refers to the percolation pace resulting when water at atmospheric pressure is making freely available at the ground Earth's surface (Hillel 1982). Infiltration is thus dependent upon soil shape (surface ascendancy), such as moisture, matric potential, pore size distribution, whereas the percolation rate is supply controlled. The infiltration rate can be greater than the infiltration if water is ponded sufficiently deep on the soil surface or the infiltration rate can be smaller if water is supplied at a lower rate than the infiltration. If a shallow layer of water is instantaneously applied and maintained at the surface of an initially unsaturated soil, the full range of soil infiltration may be measured (Figure4.2). The infiltration rate decreases with time to a constant steady rate while the

Cumulative infiltration (the time integral of the infiltration rate) increases with time but with a decreasing slope (Hillel 1982).



### Figure 4.2: Time dependence of infiltration and of cumulative infiltration (*adapted from Hillel 1982*).

4.10.1 Procedure:

- Select a site for assembling the soil sample at different depth and before experiment the samples should be oven prohibitionist soil.

- Quickly pour water into the cylinder to a ponding depth that you have selected and immediately begin the stop watch.

- Refill the water cylinder and continue adding water to the soil column to maintain a constant ponding depth. Carefully record the total volume of water added to the soil column.

- After 2-3 minutes, halt the stop watch and record both the volume of water added to the soil column (following initial Ponding) and the time elapsed since you reached the initial ponding depth.

- Repeat the experiment at a Laboratory disturbed by soil different layers.

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#### 4.11 Iron Test

Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, physiological status, sex and iron bio-availability and range from about 10 to 50 mg/day. Anaerobic ground waters may contain iron. Taste is not usually noticeable at iron concentrations below 0.3 mg/l, although turbidity and colour may develop in piped systems at levels above 0.05 to 0.1 mg/l.

Sources of pollutants include iron ore mine tailings, Wastewater from the manufacture of steel and other alloys of iron, and wastewater from the manufacture of steel and other alloys of iron, and wastewater from other application using iron compounds, e.g., dyeing of cloth, blueprints, water purification, ceramic, fertilizer, production of ammonia, fertilizer, pesticides and wood preservation.

#### Effects:

Long time consumption of drinking water with a high concentration of iron can lead to liver diseases (hemosiderosis). Iron also promotes the growth of iron-bacteria. This gives a rusty appearance to the waters. Colonies of these bacteria may also from a slime which causes problems in water closets, pipes, pumps and distribution system. Excessive iron can be toxic, because free ferrous iron reacts with peroxides to produce free radicals, which are highly reactive and can damage DNA, proteins, lipids, and other cellular components. Thus, iron toxicity occurs when there is free iron in the cell, which generally occurs when iron levels exceed the capacity of transferring to bind the iron.

Large amounts of ingested iron can cause excessive levels of iron in the blood and can cause damage to the cells of the gastrointestinal tract that prevens them from regulating iron Page 59 National Institute Of Technology Rourkela -769008, Odisha राष्ट्रीयप्रौंपोगिकीसंस्थालराउरकेला-७६९००८, ओडिश

absorption. High concentrations of iron in blood damage cells in the heart, liver and elsewhere, which can cause serious problems, including long-term organ damage and even death.

Humans experience iron toxicity above 20 milligrams of iron for every kilogram of mass, and 60 milligrams per kilogram is alethal dose, over consumption of iron, often the result of children esting large quantities of ferrous sulfate tablets intended for adult consumption, is one of the most common toxicological causes of death in children under six.

Iron gives the water unpalatable taste and undesirable appearance. Iron levels exceeding 0.3 mg/l limit could already impart red, brown, or yellow staining of laundry, glassware, dishes and household fixtures such as bathtubs and sinks. The water may also have a metallic taste and an offensive odor. Iron restricts and clogs water system piping and fixtures.

#### 4.12 Fluoride Test

Fluorides are organic and inorganic compounds containing the element fluorine. As a halogen, fluorine forms a Monovalent ion (-1 charge), fluoride forms a binary compound with another element or radical. Examples of fluoride compounds include hydrofluoric acid (HF), sodium fluoride (NaF), potassium fluoride (KF) and calcium fluoride (CaF2). Fluoride can enter groundwater by natural processes. Weathering can leach out fluoride from bedrock with high fluoride content in the soil. Traces of fluorides are present in many waters. Higher concentrations are often associated with underground sources. In groundwater, fluoride concentrations vary with the type of rock that the water flows through but do not usually exceed 10 mg/l.

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#### Effects:

Presence of large amounts of fluoride is associated with dental and skeletal fluorsis (1.5 mg/l) and inadequate amounts with dental caries (< 1 mg/l). There are many method to find out the fluoride concentration in water: Preliminary Distillation Step, Ion-Selective Electrode Method SPADNS Method, Complex one Method, Ion-Selective Electrode Flow Injection Analysis. In the present method SPADNS method was used to detect Fluoride concentrations.

#### 4.12.1 SPADNS Method

The SPADNS colorimetric method acting is based on the reaction between fluoride and a zirconium –dye Lake. Fluoride reacts with the dye lake, dissociating of it into a colorless complex anion (ZrF62-); and the dye. As the amount of fluoride growth, the color produced becomes progressively ignitor.

The chemical reaction rate between fluoride and zirconium ions is influenced greatly by the acidity of the reaction mixture. If the proportion of acid in the reagent is increased, the reaction can be made almost instantaneous. Under such conditions, however the effect of various ions differs from that in the conventional alizarin methods. The selection of dye for this rapid fluoride method is governed largely by the resulting tolerance to these ions.

#### 4.12.2 Procedure

-Preparation of standard curve: Prepare fluoride standards in the range of 0 to 1.40 mg F-/L by diluting appropriate quantities of standard fluoride solution to 50mL with distilled water. Pipette 5.00mL each of SPADNS solution and Zirconyl-acid reagent, or 10.00mL mixed acid-zirconyl-SPADNS reagent, to each standard and mix well. Avoid contamination. Set photometer to zero absorbance with the reference solution and obtain absorbance readings of National Institute Of Technology Rearches -00000, Oddata appropriate/AMML appropriat

standards. Plot a curve of the milligrams fluoride-absorbance relationship. Prepare a new standard curve whenever a fresh reagent is made or a different standard temperature is desired. As an alternative to using a reference, set photometer at some convenient point (0.300 or 0.500 absorbance) with the prepared 0 mg F-/L standard.

-Sample Pretreatment: If the sample contains residual chlorine, remove it by adding 1 drop (0.05mL) NaAsO2 solution /0.1mg residual chlorine and mix.(sodium Arsenite concentrations of 1300 mg/L produce an error of 0.1 mg/L at 1.0 mg F-/L.)

-Color development: Use a 50.00mL sample or a portion diluted to 50ml with distilled water. Adjust sample temperature to that used for the standard curve. Add 5.00mL each of SPADNS solution and Zirconyl-acid reagent, or 10.00mL acid-zirconyl-SPADNS reagent; mix well and read absorbance, first setting the reference point of the photometer as above. If the absorbance falls beyond the range of the standard curve, repeat using a diluted sample.

collected through the conical part in a beaker and therefore the final iron concentration was measured in the Atomic Absorption Spectrometer (AAS). The rate of filtration was noted and for every adsorption media, three samples were tested and average iron concentration was considered for analyzing

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### CHAPTER 5

### **ANALYSIS OF RESULTS**

#### 5.1 Grain Size Distribution

The Grain sized Distribution was characterized in four river bank site Brahmani, Koel, Sankha, Budhabalanga rivers near Rourkela. It was necessary to develop an experimental protocol to ensure representative samples. Geotechnical engineers only distinguish between well-graded and poorly graded sands [ASTM D 2487 (1994), or Unified Soil Classification System (USCS)]. This determination is based on the coefficient of uniformity, C<sub>u</sub>, and the coefficient of curvature, C<sub>c</sub>, defined by

$$c_u = \frac{D_{60}}{D_{10}} \tag{1}$$

and

$$c_{c} = \frac{(D_{30})^{2}}{D_{60} D_{10}}$$
(2)

Where D60, D30, and D10 refer to particle-size diameters corresponding to 60, 30, and 10% passing, respectively. If sand contains less than 12% fines and if  $C_u$  is  $\geq 6\%$  and  $1 \leq C_c \leq 3$ , then it is classified as well graded. If  $Cu \leq 6$  or  $C_c < 1$  or  $C_c > 3$ , then it is classified as poorly graded (see Peck et al. 1974, p. 9 regarding gap-graded sand). The results obtained in the present work are shown in Figure 5.1. The relevant geo technical parameters are presented in Figure 5.1, where it can be seen that the average mean particle size,  $D_{50}$ , is ranging between 0.1 mm to 0.6 mm. Thus, these soils are slightly on the sandy silt side. Of course, the USCS does not actually distinguish whether sandy silt sand is poorly graded or well-graded. However, strictly abiding by the Unified Soil Classification System (USCS) would not convey the broad range of particle sizes. However, the average coefficient of uniformity, Cu, greater than 6 and the average coefficient of curvature, Cc, between 1 and 3, has been described as well-graded. One of the reasons that geotechnical engineers prefer to use the phrase ''well-

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graded" instead of 'poorly sorted" is that the former connotes the idea that such soil compacts well, producing a good, dense structural fill. But as the uniformity coefficient, Cu = D60 /D10 increases, it can result differently. In particular, it has been known for a long time that soils having a Cu less than 10 are self-filtering with respect to a hydraulic gradient, but soils having a Cu more than 20 are likely to be internally erodible, and, hence, unstable (United States Bureau of Reclamation 1960; Kovacs 1981; and Skempton and Brogan 1994).





Figure 5.1: Grain size distribution of soil samples

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As shown in Figure 5.2, the soils of Brahmani, Koel, Sankha and Budhabalanga have  $C_u$  values 8, 6, 15 and 3.5 respectively. The values of  $C_c$  of all the soil samples were found to be 1.62, 1.12, 6 and 2.03 respectively. As we discussed previously, the average coefficient of uniformity, Cu, greater than 6 and the average coefficient of curvature, Cc, between 1 and 3, has been described as well-graded. But we found the  $C_u$  of soils of Brahmani, Koel, Sankha samples are with in range, but the soils of Budhabalaga is not well graded.

Furthermore, the mid portion of the particle size distribution satisfies the criteria for instability of the soil samples at Sankha river described by de Mello (1975), Kezdi (1979), and Kenney and Lau (1985, 1986), and expanded by Skempton and Brogan (1994). Hence, the soil samples at Sankha river may be internally erodible, that is, it is potentially susceptible to "segregation piping." This occurs even though lunar soil is not gap-graded and, indeed, satisfies the criteria for well-graded (Figure 5.2). It is simply a consequence of the very broad particle size distribution, which in turn is due to the very dynamic environment in which soil is formed and deposited.

Figure 5.2: Coefficient of uniformity and Coefficient of curvature plots

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A good curve fit of the grain-size curve is essential for the prediction of a reasonable soil-water characteristic curve. The minimum particle size was also found to have an influence on the prediction of the soil-water characteristic. If the minimum particle size variable is too low, the Overabundances of clay size particles would dominate the prediction. If the minimum particle size is too high, an absence of smaller particles would result in the soil drying out prematurely. The prediction of soil-water characteristic curve from the grain-size distribution was found to be particularly accurate for sands, and reasonably accurate for silts. Clays, tills and loams were more difficult to predict although the accuracy of the prediction algorithm appears to be reasonable. Results tended to be sensitive to the packing porosity and more research is required in this regard.

#### 5.2 Liquid Limit (LL) Test

In the lab, the LL is defined as the moisture content (%) required closing a 2-mm wide groove in a soil pat a distance of 0.5 in along the bottom of the groove after 25 blows. Its value is generally below 100. Numbers of blow ranging between 15 to 35 were given to each sol sample and the results are shown in Figure 5.3. It has been found that the average liquid limit for soil samples collected from Brahmani river, Koel river, Sankha river and Budhabalanga river are 23.56%, 25.72%, 24.96% and 27.27%, respectively. It is observed that all samples lie in within the range which helps water to flow through soil in the porous media .These results were then used to find the flow index as seen below (Figure 5.3).





#### Figure 5.3: Liquid limits of soil samples

#### 5.3 Plastic Limit Test

In lab, Plastic limit as the moisture content at which a 3mm diameter rod of soil begins to crumble. Since the volume of soil used for the moisture content measurement is very small, significant moisture loss can occur while obtaining the moist weight of the soil specimen. The

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best way to minimize this error is to obtain the moist weight of the soil rod as quickly as possible after it crumbles. It is observed that the average Plastic limit for soil samples collected from Brahmani river, Koel river, Sankha river and Budhabalanga river are 17.88%, 20.58%, 17.41% and 21.35%, respectively. Soil's plastic limits are very sensitive to moisture unless the combined silt and clay contents are about 20 percent. The relationship obtained for water contents greater than the liquid limit to less than the plastic limit of the soil has been experimentally verified. According to IS soil classification system, organic clay has high compressibility and liquid limit greater than 50. Similarly, it has medium to high dry strength and high toughness but dilatancy is very slow.

The value found for the Plasticity Index is crucial when determining the characteristics of a sample (Figure 5.4). A lower Plasticity Index (10-15%) indicates that there is significant silt in the sample. A higher Plasticity Index (15-100%) indicates that there is significant clay in the sample. The Plasticity Index for this sample came out to be 15.6%. This falls just above the Atterberg Limits for silts.

Liquid limit typically ranges anywhere from 20% for silts to over 100% for high plasticity clays. When the plastic limit is equal to or greater than the liquid limit, the plasticity index is reported as zero. Plasticity index typically ranges anywhere from near 0% (i.e.; a non plastic soil) for silts to over 50% for high-plasticity clays. Above case are applicable if only the soil is sandy soil. If liquid limit <30% that is low plasticity soil it is like silt types. If liquid limit >50% that is high plasticity soil it is like clay types. Figure 5.5 shows liquid limit, plastic limit and plastic index of all type of soils.

#### Figure 5.5: Liquid limit, Plastic limit and Plastic Index of all the soil samples

#### 5.4 Shrinkage Limit tests

Shrinkage limit: the water content below which soils do not decrease their volume any more as they continue dry out needed in producing bricks and ceramics. From the graph 20% for silts to over 100% for high plasticity clays. Plasticity index typically ranges anywhere from near 0% (i.e.; a no plastic soil) for silts to over 50% for high-plasticity clays. Aside from four soils of

#### Figure 5.4: Casagrande's Plasticity Chart (USCS)

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varying clay mineralogical compositions from the field, two commercial clays (i.e., kaolinite and bentonite), and four soil mixtures were used in the present work. The volume of soil does not decrease when the water content is reduced below the Shrinkage limit. The graphs below results of shrinkage limits as 18.86%, 29.58%, 26.31%, 26.90% for Brahmani, Koel, Sankh and Budhabalanga river soils respectively. It shows the amount of water sufficient to fill all the pores of the soil and is just saturated. It is an indicator of how much volume change is possible as changes in water content above the Shrinkage Limit occurs.



Figure 5.6: Shrinkage limit of all the soil samples

#### 5.5 Specific Gravity (Gs)

It is also known as relative density, it can be viewed as the mass of a given volume of soil solids normalized relative to the mass of an equivalent volume of water. Specific gravity is typically expressed using three significant figures. For sands, Gs is often assumed to be 2.65 because this is the specific gravity of quartz. Since the mineralogy of clay is more variable, Gs for clay is more variable, and is often assumed to be somewhere between 2.70 and 2.80 depending on mineralogy. Figure 5.7 illustrates the results the specific gravity of different types of soil samples respectively. The value shows, the soil sample is organic clay because the range of specific gravity for organic clay is 2.58 to 2.65 (IS soil classification system). We know that smaller the particle size, higher the value of specific gravity and vice versa.

#### Figure 5.7: Specific gravity of all the soil samples

#### 5.6. XRD analysis

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Mineralogical composition of the soil is very important. It has great bearing on the engineering Properties. The XRD method is one of the very useful methods, which is applied to find out the mineralogical composition of soil. All the samples were analyzed with X-Ray diffraction to determine the mineralogical composition of the soil, the results indicate that the major mineralogical composition for all the samples remain similar. The results of the X-ray diffraction tests performed on each Four samples are presented in Table 5.1. Our results for mineralogical composition determined by XRD are comparable with the internationally reported values for the similar crystal structures. The intensity curves and stick pattern for all the major minerals is given in Table respectively.

 Table 5.1.Mineral composition of soil samples for four selected locations from study area

Location	Compound Name	Chemical Formula
	Calcite,	CaCO <sub>3</sub>
Budhalanga	Smectites,	A 0.3D 3[T <sub>4</sub> O <sub>10</sub> ] Z2·H <sub>2</sub> O
	Vermiculites	Mg1.8Fe <sub>2</sub> +0.9Al <sub>4</sub> .3SiO <sub>10</sub> (OH) <sub>2</sub> •4(H <sub>2</sub> O)
	Kaolinite,	Al <sub>2</sub> Si <sub>2</sub> O <sub>5</sub> (OH) <sub>4</sub>
Brahamani	Dolomite,	(Ca Mg) (CO <sub>3</sub> ) <sub>2</sub>
	Chlorites	(Mg,Fe) <sub>3</sub> (Si,Al) <sub>4</sub> O <sub>10</sub>
	Smectites	A 0.3D 3[T <sub>4</sub> O <sub>10</sub> ] Z <sub>2</sub> · n H <sub>2</sub> O
Koel	Aragonite,	CaCO <sub>3</sub>
	Chlorites	(Mg,Fe) <sub>3</sub> (Si,Al) <sub>4</sub> O <sub>10</sub>
	Calcite,	CaCO3
Sankha	Kaolinite,	Al <sub>2</sub> Si <sub>2</sub> O <sub>5</sub> (OH) <sub>4</sub>
	Vermiculites	Mg1.8Fe <sub>2</sub> +0.9Al <sub>4</sub> .3SiO <sub>10</sub> (OH) <sub>2</sub> •4(H <sub>2</sub> O)

The extent of this study is too limited to permit any generalized conclusions concerning clay mineral Present in soil samples. The information does indicate that clay mineral available within the soil profile. Decomposition of both Kaolinite and montmorillonite was observed in the surface profiles. The overall picture, however, indicates very little change in chemical composition between the soils and parent sediments. Budhabalang and Koel river samples show the presence of Calcite, Smectites, Vermiculites, Aragonite, and Chlorites that means these are under Carbonates, Chlorites Mineral groups, which is helping us to remove the iron form the water. Sankha and Brahmani river samples come under the clay mineral groups which help to remove the pollutants also best results infiltration capacity.

#### Table 5.2. Physical Properties of Budhabalanga River

Physical parameters	Values	Physical parameters	Values
Colour	Light red	Shape	Rounded/sub- rounded
Silt & clay (%)	87	uniformity Co-efficient ,Cu	3.50
Fine sand (%)	13	Co-efficient of curvature, Cc	2.03
Medium sand (%)	0	Specific gravity(G)	2.54
Coarse sand (%)	0	Plasticity index	Non-plastic

#### 5.7. Infiltration analysis

In the previous section, it has been observed that the soil samples of river Sankha is having impervious drainage characteristics and may create piping effect. Therefore, it is not used for further analysis of infiltration test and water quality tests.

From graphs (Figure 5.8) of infiltration rates against time it is found that initially infiltration rates were high and decreased with time up to constant infiltration rate. Experience indicates that the infiltration rate of a given soil can be high or low, depending on physical status and management history. Infiltration rate is often critically influenced by surface soil conditions, but subsurface layers also are sometimes limiting. Water distribution in the profile and depth of water applied are modifying factors. The infiltration rate can be undesirably high or undesirably low. It is the low end of the range that may be a critical limiting factor in the agricultural use of alkali soils.





#### Figure 5.8: Infiltration Rate of all the soil samples at different depths

Times (nain)

It has been observed the rate of flow of water is 0.18 litre per hour for the soils of River Brahmani for natural flow condition, which is very low. If we increase the pressure head, its values go up and rate of infiltration increases. We used soil of Brahmani river in addition to other filters to test the water quality improvement. The best fit equation observed for the soil of Brahmani can be written as :

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#### 5.8. Water Quality analysis

As we discussed in previous chapters, water quality analysis using different low cost filter materials has been carried out. After completing all the physical and chemical analysis of soil samples we checked all the requirements of soil samples for water quality analysis. IT has been observed that the soil Samples of River Brahmani has highest rate of infiltration for soil column of 50 cm depth. Here, both combination of soil having various thickness and different layers of different amount of filter materials were used for analysis. Known concentration of iron and fluoride solution was passed through and filtrate was collected in a bottom conical portion (Figure 3.2) and then it is filtered through filter paper. Final concentration was measured with AAS (Atomic Absorption Spectrometer).

#### Water quality improvement in sediment

First of all, only sediment was used for removal of iron. We observed the water quality improvement of different soils without providing filter material. It has been observed that 20 % of removal of iron is removed in each type of soil (Figure 5.9). The results indicate better removal of iron in Budhabalanga samples.

#### Figure 5.9: Iron removal in Different types of soils (50 cm depth)

#### Water quality improvement Using Sugarcane Bagaase

Then we used Budhabalanga samples as water quality analysis using Sugarcane bagasse as a filter material. The results shows that 80% remove iron in all layers but center layers gives better results as compare to other two. The results are shown in Figure 5.10.

Figure 5.10: Iron removal in Sugarcane Bagasse (1 cm depth = 24.2 g) Different Layers

Water quality improvement Using Rice husk

Rice husk is used as removal of Iron. It is provided at 3 different layer top, bottom and center. The better result showing in center layer in which 100% of iron is removed. The results are shown in Figure 5.11. Figure 5.11: Iron removal in Rice husk (1 cm depth = 20.9 g) Different Layers

#### Water quality improvement Using Zeolite

As we saw in figure 5.11 Rice husk gives remove 90% Iron. But we not decided either it gives more improvement results which layers. so after decide soil samples we provided each layers .its gives better results both center & bottom .the 100% remove iron . The results are shown in Figure 5.12.

Figure 5.12: Iron removal in Zeolite (1 cm depth = 39 g) Different Layers

#### Water quality improvement Using Wood coal

Wood coal use as removal of iron. It is provided at 3 different layer top, bottom and center. The better result showing in center layer. Which is 100% remove the iron the results are shown in Figure 5.13. Figure 5.13: Iron removal in Wood coal (1 cm depth = 33.2 g) Different Layers

#### Fluoride improvement

Seventy five of wood coal Mix with 25% of lime powder use as removal of fluoride. The initial iron 10mg/l to 11mg/l concentration was each three layers, top &bottom, top & center, only bottom, only center, only top as 10ppm, 11.4ppm, 9.1ppm, 10.83ppm, 10ppm, 10.01ppm, and 10ppm respectively. And removal iron 73 % obtained in all samples. It has given the good result. The results are shown in Figure 5.14.

Figure 5.14: Fluoride removal in Wood coal (33.37g) + Lime (11.125) (1 cm depth)

**Different Layers** 

#### 5.9. Compression of filter model

After investigating all the water Quality analysis of different filter materials at different

location (Top, Center& bottom) we study rate of filtration is given (Table 5.3.)

#### Table 5.3. Rate of infiltration at different Layers

Layers	Filter materials				
	Sediment	Sediment Sugar Cane Rice Husk Zeolite Wood Coa			
Upper	-	1.51	1.17	1.61	1.25
Center	-	1.03	1.5	1.73	2
Bottom	-	1.9	1.31	2.03	1.26

We observed Rate of filtration combination of both different filter materials with different

location after that we see from above combination the quality improvement.

#### Table 5.4. Water Quality Improvement At different Layers

Layers	Filter materials				
	Sediment	Sugar Cane	Rice Husk	Zeolite	Wood Coal
Upper	-	4.096	3.049	1.01	1
Center	-	0.823	0.329	0.023	0.13
Bottom	-	3.28	2.72	0.096	0.91

Abhijeet (2014) developed a filtration model in his B.tech project. Model has been created for study of low price water purification technique (figure 5.20 (A)). According to the requirement of the project the development of the cylindrical tube is maintained as follows.

- Length=15 cm.
- Internal diameter = 7.3 cm.
- Base and top is covered with a sponge of 2 cm thickness.
- From the base, outlet pipe is extended to collect water with a tap regulate filtered water.
- Top of the cylinder filter bottle was covered with a cap of 0.5mm thickness
- A hole of 12mm diameter was made to connect with the inlet pipe.



Figure 5.15: Filtration model (a) Abhijeet (2014) (B) Chittaranjan (2014)

Comparative study between Approach 1 and Approach 2 indicate (figure 5.16) that both Performing similar in terms of head loss and filtrate quality improvement. Use of low cost filter materials of these two was significantly different. In approach 1, he can use various herbal materials and we use various low cost filters. Herbal media best for biological removal but not satisfactory results show in iron removal. Comparisons were also made between placing of filter materials, He can use randomly. But we use each different position that gives a profile that which place is better. I also analysis different depth soil columns which dised the rate of outflow is develop a cordial relation in between inflow or head monitoring. In place of soil he uses sand as the thematic layers. So he cannot maintain the inflow rates, which also affect the quality.

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Figure 5.16: Comparison of Both Filtration model

#### 5.10 Cost Analysis

Finally cost estimation is play a crucial role in this work to named as low cost. Before implementing the work, it is highly necessary, whether it is economical or not. Hence, we provided a chart for all filter materials used for experimentation is given in the table 5.1

Material	Quantity (g.m)	Cost ( )
Zeolite	39	4.18
Activate carbon	44.5	8.9
Sugarcane baggase	20.4	2.6
Rice husk	20.9	5.8
Wood coal	33.2	3.32

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### CHAPTER 6

# SUMMARY AND CONCLUSIONS

#### SUMMARY AND CONCLUSIONS

The present theoretical investigation supported by experimental observation is made a low cost filter materials having different combination. On the basis of the investigations infiltration rate, soil properties, and filter materials characteristics.

The available information revealed that there is a vest scope for development and exploitation of ground water as well as surface water .A planned development of available water may not only contribute as a sustainable source of domestics water supply But also quality improvement Before goes to the preliminary treatment.

The conclusions from this present study can be summarizes as follows:

- The Study of physical properties of soil very useful, to know the basic characteristics for proper infiltration rate that may be used for groundwater recharge and river bank filtration.
- 2. The test results of the infiltration capacity, coefficient of uniformity (C<sub>u</sub>), and the coefficient of curvature (C<sub>c</sub>), Shrinkage Limit, Plastic Limit, Liquid Limit and specific gravity, rate of water supply, and size of soil column available at different river sites shows that, except soil samples obtained from the bank of river Sankha, all three soil samples collected from Brahmani, Koel and Budhabalanga are suitable for infiltration tests and water quality analysis.

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- The rate of infiltration of different depths (10 cm, 20 cm, 30 cm, 40 cm & 50 cm) of all the three soil samples indicates that the rate of infiltration is highest and uniform. However, the better results are obtained when soil samples of Budhabalanga river bank are used for the analysis.
- The soil column of 50 cm obtained from Budhabalanga river bank was considered for water quality improvements in high concentration Iron and Fluoride. The percentage of soil removal was 20 %.
- After first experiment with only soil column, a chemical Zeolite was tested for their suitability to remove Iron and Fluoride. The percentage of soil removal was 100 %.
- 6. Further, the different low cost filter material (Sugarcane Baggase, Rice Husk and Wood Coal) was used for water quality improvement. The amount and location (Top, bottom& Center of the soil column) of the filter material was varied and tested for water quality improvement. The Particle Size of different filter materials (Sugarcane Baggase, Rice Husk, and Wood Coal) was between 425 micron to 600 micron.
- 7. The percentages of soil removal in all the three materials were 100%. However, the most effective results are obtained when the filter material was place at the centre of the soil column. This may be due to the fact that, the suspended material are removed in the

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beginning, the dissolved material is removed at the centre by the filter and the remaining water flows freely through the soil column below the filter material.

- 8. A comparison was made with the previous study carried out with similar material having low quantity and very small soil column. The soil column (50 cm) and filter material Sugar Cane Baggase provided the best result without the use of any chemical.
- It is observed that the cost of Sugar Cane Baggase as filter material was minimum. However, the wood coal and rice husk are also very less expensive. They are chemical free too.

#### **Remarks for Future Scope of Study**

The present work leaves a wide scope for future investigators to explore many other aspects of Water Quality analysis. Efforts are needed to promote other parameter estimation. The traditional water treatment system under economic conditions may be suitability replaced by low cost filter using materials like activated carbon, made in laboratory. On the basis of the Different surface area have being 0.1-0.01 micron size Filter water pass through it.

There is a urgent need to focus on alternative to developed proper filter materials having sediment silt & clay pre combination along this activated carbon to increase rate of flow. This leads to the need for extending domestics water facilities.

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To design potable water purifiers, community level water purifier at low cost base on locality available materials.

To patent the develop low cost filter, Design of potable filter & community able filter, Home made use, also provide UV use for kill bacterial and also use image process for identification of metal iron present in water.

### **CHAPTER 7**

### REFERENCES

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### **APPENDIX-A**

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# **APPENDIX-B**



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#### Publications from the Work

#### A: JOURNAL PUBLICATIONS

1. C.Dalai, R.Jha. Review on water treatment techniques used for Riverbank Filtration. *International Journal of Civil Engineering Research*, ISSN 2278-3652. Vol. 5, Number 3, 2014. pp 221-226.

2. C.Dalai, R.Jha. A Preliminary Experimental Analysis of Infiltration Capacity through Disturbed River Bank Soil Samples. *International Journal of Engineering Research and Applications*, ISSN 2248-9622. Vol. 2, 2014. pp 24-29.

#### **B: CONFERENCE PROCEEDINGS**

- C.Dalai, R.Jha. Critical Analysis of Filter Materials for River Bank Filtration, Proceedings National Seminar of Recent Approaches to Water Resource Management RAWRM-2013 Conference in Jharkhand, I.S.M Dhanbad, Dec 9-10, 2013.
- C.Dalai, R.Jha. Water Quality Improvement Using Different Filter Material in odisha, Proceedings of International Symposium on Integrated Water Resources Management (IWRM–2014) Conference in CWRDM, Kozhikode, Kerala, India, February 19–21, 2014.

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He passed his Senior Secondary School Examination (Diploma) of the State Council for Technical Education and Vocational Training Odisha in first division with distinction in Civil Engineering in 2008.

He was admitted to B.Tech degree course in Civil Engineering at Kalinga Institute of Industrial Technology, Bhubaneswar in 2008. He completed the degree with first division (OGPA-8.45) in 2012.

In year 2012 He joined "Master of Technology" two year Post Graduation degree program in Water resources Engineering in Department of Civil Engineering at National Institute of Technology Rourkela. After completing the entire prescribed course work successfully, He has submitted the thesis in partial fulfillment of the requirement for the award of degree of "Master of Technology".

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