



ADSORPTION OF LEAD AND ZINC FROM
AQUEOUS SOLUTION USING BANANA/COTTON
BLENDED NONWOVEN FABRIC

A PROJECT REPORT

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in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY
in
TEXTILE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE - 641 049
(An Autonomous Institution Affiliated to Anna University, Chennai)
MAY – 2013



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BONAFIDE CERTIFICATE

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ACKNOWLEDGEMENT

I wish to express my sincere gratitude to our beloved Co-Chairman, **Dr. B. K. Krishnaraj Vanavarayar**, **Mr. Shankar Vanavarayar**, Joint Correspondent and **Dr. S. Ramachandran**, Principal for their support and allowing utilizing the facilities of the institution.

I express my whole hearted thanks to **Dr. Bharathi Dhurai**, Head of the Department, Kumaraguru College of Technology, for having been a source of encouragement and for instilling the vigour for doing this project

It give me great pleasure to express my deep sense of gratitude to my supervisor, **Mr.S.Ariharasudhan**, Assistant Professor , Department of Textile Technology, Kumaraguru College of Technology for his innovative guidance, expert suggestions and constant encouragement at every step in the project.

I would like to dedicate my hearty and sincere thanks to **Mr. Gopinath**, Senior Project officer, KCT- TIFAC Core , Kumaraguru College of Technology for importing necessary guidelines, valuable suggestions for completing the project successfully.

I would like to express my thanks to all the teaching and nonteaching staff for their help during this project.

I also thank my parents and friends for their continuous support throughout my course of study.

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ABSTRACT

Environmental pollution caused by toxic heavy metals is one of the most pressing problems in many densely populated cities worldwide. The industrial and domestic wastes responsible for various damages to the environment adversely affect the health of the human population. The major toxic metal ions hazardous to humans as well as other forms of life are chromium (Cr), iron (Fe), selenium (Se), vanadium (V), copper (Cu), cobalt (Co), nickel (Ni), cadmium (Cd), mercury (Hg), arsenic (As), lead (Pb), zinc (Zn), etc. Several events resulting from heavy metal contamination in the aquatic environment increased the awareness of the heavy metal toxicity. Therefore, it is necessary to remove these metals from industrial effluents before discharging aqueous waste into the environment.

In this study comparative adsorption studies of heavy metal ions (Pb²⁺, Zn²⁺) on banana fibre were performed to investigate the uptake performances. For this purpose banana fibre was extracted from banana stem by mechanical method and then softening the fibre using alkali (NaOH) treatment. The needle –punched fabrics were made from parallel laid webs. Then batch adsorption experiments were performed at two different initial heavy metal ion concentrations (500, 700 mg/L), at constant temperatures (298.15 K), time period (30, 60, 90 min) and pH of solutions(4, 7, 9). The results indicated that the uptake performance of banana fibre significantly changed with pH, adsorbent dosage, and concentration. Batch studies indicated that banana fibre was effective in removing 95.5% of lead and 98% of zinc. The equilibrium time was determined to be 60 min and optimum pH range was found to be 6.5 to 7.0.

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LIST OF ABBREVIATIONS

AAS	- Atomic Adsorption Spectroscopy
pH	- power of hydrogen
ASTM	- American Society For Testing And Materials
NaOH	- Sodium Hydroxide
HCL	- Hydrogen Chloride
Cu	-Copper
Cd	- Cadmium
Ni	- Nickel
Pb	- Lead
Zn	- Zinc
Ag	- Silver
Cr	- Chromium
Hg	- Mercury
Fe	-Iron
Co	- Cobalt
As	- Arsenic

CHAPTER-1
INTRODUCTION

1.1 Introduction

In recent years, different approaches have been discussed to tackle man made environmental hazards. Clean technology, eco-mark and green chemistry are some of the most highlighted practices in preventing and or reducing the adverse effect on our surroundings. Among many engineering disciplines – Civil Engineering, Mechanical Engineering, Electrical Engineering etc., Textile Engineering has a direct connection with environmental aspects to be explicitly and abundantly considered. The main reason is that the textile industry plays an important role in the economy of the country like India and it accounts for around one third of total export. Out of various activities in textile industry, chemical processing contributes about 70% of pollution. It is well known that cotton mills consume large volume of water for various processes such as sizing, desizing, scouring, bleaching, mercerization, dyeing, printing, finishing and ultimately washing. Due to the nature of various chemical processing of textiles, large volumes of waste water with numerous pollutants are discharged. Since these streams of water affect the aquatic eco-system in number of ways such as depleting the dissolved oxygen content or settlement of suspended substances in anaerobic condition, a special attention needs to be paid. Thus a study on different measures which can be adopted to treat the waste water discharged from textile chemical processing industries to protect and safeguard our surroundings from possible pollution problem has been the focus point of many recent investigations.

In this study comparative adsorption studies of heavy metal ions (Pb²⁺, Zn²⁺) on banana fibre were performed to investigate the uptake performances.

1.2 Objectives

The main objectives of this study are

- To extract the banana fiber from banana stem for metal ion absorption.
- To softening the extracted fibre for further processes.
- To develop needle punched non-woven fabric using Banana / Cotton (75/25) blended fibre.
- To analyze the adsorption of selected metal ions (Zn²⁺, Pb²⁺) in an aqueous solution using developed fabric.

CHAPTER-2
LITERATURE REVIEW

2.1 Statement of Pollution Problem

The greatest demand for metal sequestration today comes from the need to immobilize the metals released to the environment or mobilized by and partially lost through human technological activities. It has been established that dissolved metals (particularly heavy metals) escaping into the environment pose a serious health hazard. They accumulate in living tissues throughout the food chain, which has humans at its top, multiplying the danger. Thus, it is necessary to control emissions of heavy metals into the environment.

Due to increase in the world population and development of industrial applications, environmental pollution problem became important. Communities produce both liquid and solid wastes. The liquid waste-wastewater- is essentially the water supply of the community after it has been used in a variety of applications. In recent years, heavy metal concentrations, besides other pollutants, have increased to reach dangerous levels for living environment in many regions.

The presence of toxic and polluting heavy metals in wastewaters from industrial effluents, water supplies and mine waters and their removal has received much attention in recent years. The amount of heavy metals that industrial wastewaters often contain is considerable and would endanger public health and the environment if discharged without adequate treatment.

Heavy metals are elements such as Cu (Copper), Cd (Cadmium), Ni (Nickel), Pb (Lead), Zn (Zinc), Ag (Silver), Cr (III) (Chromium), Hg (Mercury), Fe (Iron), Co (Cobalt), As (Arsenic) which are usually associated

with toxicity and natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. Among them only Cu, Pb, Cd, and Ni were studied in this thesis.

Table: 2.1 Ranking of risks

Ranking of risks associated	Environmental Risk
High	Cd Pb Cr
Medium	Co Cu
Low	Al Fe

Copper is widely distributed in nature as the free metal and more commonly, as compounds in various ores such as cuprite (Cu₂O), chalcopyrite (CuS·FeS), azurite (Cu (OH) 2·2CuCO₃) and malachite Cu₂CO₃ (OH) 2. There are also deposits of cupric chloride and cupric arsenide.

Copper is used mainly in the production of alloys with zinc, nickel and tin, as a catalyst in the chemical industry, in the electrochemical industry where it is used in wires, generators, transformers and heat exchangers, and of course in the production of piping for water supply. Copper salts are used as pigments

and fungicides, and also biocides for controlling slime and in human and animal waste.

Copper can exist in four valence states — the native element Cu0 and the ions 1+, 2+, and 3+. The most common form is as Cu²⁺. Cu+ salts exist but are rapidly oxidized to Cu²⁺. In water, most cupric Cu²⁺ salts readily dissolve to form an aqua complex Cu(H₂O)₄²⁺, and the water molecules can then be replaced by a variety of ligands to form different complexes. Some of these organic complexes are essential to life, principally haemocyanin. Copper complexes found in water [CuCO₃(aq)]₀, [Cu(CO₃)₂]²⁻, [CuOH]⁺, [Cu(OH)₃]⁻ and [Cu(OH)₄]²⁻ forms.

Lead is rarely found as the free metal in nature, but it is present in several minerals, principally in galena (PbS) the main source for lead production. It is also found as anglesite (PbSO₄) and cerussite (PbCO₃).

Lead is one of the most commonly used non-ferrous metals. It has many applications; its largest use is in making storage batteries, most of which are recycled. As a result of its resistance to corrosion and its malleability, it finds use in building constructions, storage tank lining and corrosive liquid containers. Other uses of the metal are for radiation shielding, ammunition, solder, cable sheathing and pipework. Lead compounds are used as pigments in paints and ceramics, catalysers, antibacterial substances and wood preservatives. A major use is the production of anti-knock compounds for addition to petrol, particularly tetraethyl lead, Pb (C₂H₅)₄. The exhausts from vehicles are a major source of the environmental contamination by lead. Lead is present in exhaust gases mainly as lead halides and oxides, but incomplete combustion results in about 10% of alkyl lead compounds also being present. Other source of lead emissions are copper and nickel smelters, iron and steel

production. Estimates vary as to the importance of vehicle emissions as the source of the lead contamination.

Lead exist in the oxidation states Pb²⁺ and Pb⁴⁺, with the divalent form being the more stable in most aquatic environments. The speciation of lead compounds in water is complicated and depends upon a number of factors, principally pH, dissolved oxygen and the concentration of other organic and inorganic compounds. In surface waters, lead is presents as hydrated Pb²⁺, or [PbCO₃ (aq)]₀ in the pH range 7-9. At pH 6, Pb²⁺ and Pb(OH)⁺ are in equal concentration, whereas at higher pH values there is an increase in Pb in form of Pb(CO₃)₂²⁻, Pb(OH)⁺ and concentration of lead in waters is usually limited by the solubility of PbCO₃, and by its adsorption onto particulate matter.

2.2 Sources and Causes of Generation of Textile Effluent

Textile industry involves wide range of raw materials, machineries and processes to engineer the required shape and properties of the final product. Waste stream generated in this industry is essentially based on water-based effluent generated in the various activities of wet processing of textiles. The main cause of generation of this effluent is the use of huge volume of water either in the actual chemical processing orduring re-processing in preparatory, dyeing, printing and finishing. In fact, in a practical estimate, it has beenfound that 45% material in preparatory processing, 33% in dyeing and 22% are re-processed in finishing.

But where is the real problem? The fact is that the effluent generated in different steps is well beyond the standard and thus it is highly polluted and dangerous. This is demonstrated in Table 2.2

Table 2.2 Properties of Waste Water from Textile Chemical Processing

Property	Standard	Cotton	Synthetic	Wool
pH	5.5-9.0	8-12	7-9	3-10
BOD mg/l 5 days	30-350	150-750	150-200	5000-8000
COD mg/l day	250	200-2400	400-650	10,000-20,000
TDS mg/l	2100	2100-7700	1060-1080	10,000-13,000

2.3 Categorization of Waste Generated in Textile Industry

Textile waste is broadly classified into four categories, each of having characteristics that demand different pollution prevention and treatment approaches. Such categories are discussed in the following sections.

2.3.1 Hard to Treat Wastes

This category of waste includes those that are persistent, resist treatment, or interfere with the operation of waste treatment facilities. Non-biodegradable organic or inorganic materials are the chief sources of wastes, which contain color, metals, phenols, certain surfactants, toxic organic compounds, pesticides and phosphates. The chief sources are:

- Color & metal → dyeing operation
- Phosphates → preparatory processes and dyeing
- Non-biodegradable organic materials → surfactants

Since these types of textile wastes are difficult to treat, the identification and elimination of their sources are the best possible ways to tackle the problem. Some of the methods of prevention are chemical or process substitution, process control and optimization, recycle/reuse and better work practices.

2.3.2 Hazardous or Toxic Wastes

These wastes are a subgroup of hard to treat wastes. But, owing to their substantial impact on the environment, they are treated as a separate class. In textiles, hazardous or toxic wastes include metals, chlorinated solvents, non-biodegradable or volatile organic materials. Some of these materials often are used for non-process applications such as machine cleaning.

2.3.3 High Volume Wastes

Large volume of wastes is sometimes a problem for the textile processing units. Most common large volume wastes include:

- High volume of waste water.
- Wash water from preparation and continuous dyeing processes and alkaline wastes from preparatory processes.
- Batch dye waste containing large amounts of salt, acid or alkali.
- These wastes sometimes can be reduced by recycle or reuse as well as by process and equipment modification.

2.3.4 Dispersible Wastes:

The following operations in textile industry generate highly dispersible waste:

- Waste stream from continuous operation (e.g. preparatory, dyeing, printing and finishing).
- Print paste (printing screen, squeeze and drum cleaning).
- Lint (preparatory, dyeing and washing operations).
- Foam from coating operations.
- Solvents from machine cleaning.
- Still bottoms from solvent recovery (dry cleaning operation).
- Batch dumps of unused processing (finishing mixes).

2.4 List of Toxic Heavy Metals

- Aluminum
- Cadmium
- zinc
- Lead
- Chromium
- Copper
- Mercury
- Thallium
- Vanadium
- Nickel
- Iron

2.4.1 Lead

In the environment, Lead (Pb) is one of the major pollutants is mainly discharged from exhaust gases of automobile to environment. In addition, lead can enter to the water and environment through effluents from lead smelters, battery manufactures, painting, paper and ammunition industries. The concentration of lead ions in the industrial waste waters is in the range of 200-500 mg.dm⁻³ where very high level concentration to the standard is and should be reduced to a range of 0.1-0.05 mg.dm⁻³ before discharge to then vironment. Several methods have evolved over the years on the removal of this metal ion present in industrial waste water such as chemical precipitations, coagulation, reverse osmosis, ion exchange and adsorption. Among of these methods, adsorption appears to be the most widely used for the removal of heavy metals.

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- Declined fertility of men through sperm damage
- Diminished learning abilities of children
- Behavioral disruptions of children, such as aggression, impulsive behavior and hyperactivity.

2.4.3 Zinc

Zinc manufacturing and other industries release large quantities of metals, mainly Cd and Zn, during production. The increasing demand for alkaline zinc manganese batteries, instead of mercury based ones, brings serious problems when those batteries are not disposed of properly. Yet, another source of contamination can be due to the flooding of ore mines into the environment. Since heavy metals have toxic effects on the environment and public life, many researchers suggest a cost-effective process, such as ion exchange, for removing dissolved heavy metals from wastewaters by using naturally occurring materials. In the later years, utilization of natural zeolites to control the pollution due to the effluents polluted with heavy metal ions has increased. Natural zeolites have ion exchange capability to remove unwanted metal ions and this property makes zeolites favorable for wastewater treatment.

2.4.4 Effect of Zinc

Zinc is a trace element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell. Although humans can handle proportionally large concentrations of zinc, too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting. Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. Extensive exposure to

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Many adsorbents have been tested to remove it from aqueous solutions including bentonite, peat and zeolite. However, to improve the efficiency of adsorption process, it is necessary to develop an adsorbent that is cheaper but has high adsorption capacity such as Ligno cellulosic fibre.

2.4.2 Effect of Lead

Lead is a soft metal that has known many applications over the years. It has been used widely since 5000 BC for application in metal products, cables and pipelines, but also in paints and pesticides. Lead is one out of four metals that have the most damaging effects on human health. It can enter the human body through uptake of food (65%), water (20%) and air (15%). Foods such as fruit, vegetables, meats, grains, seafood, soft drinks and wine may contain significant amounts of lead. Cigarette smoke also contains small amounts of lead. Lead can enter (drinking) water through corrosion of pipes. This is more likely to happen when the water is slightly acidic. That is why public water treatment systems are now required to carry out pH-adjustment in water that will serve drinking purposes. For as far as we know, lead fulfills no essential function in the human body, it can merely do harm after uptake from food, air or water.

Lead can cause several unwanted defects, such as:

- Disruption of the biosynthesis of hemoglobin and anemia
- A rise in blood pressure
- Kidney damage
- Miscarriages and subtle abortions
- Disruption of nervous systems
- Brain damage

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zinc chloride can cause respiratory disorders. Zinc can be a danger to unborn and newborn children. When their mothers have absorbed large concentrations of zinc the children may be exposed to it through blood or milk of their mothers. Water is polluted with zinc, due to the presence of large quantities of zinc in the wastewater of industrial plants. This wastewater is not One of the consequences is that rivers are depositing zinc-polluted sludge on their banks. Zinc may also increase the acidity of waters. Some fish can accumulate zinc in their bodies, when they live in zinc-contaminated waterways. When zinc enters the bodies of these fish it is able to bio magnify up the food chain. Large quantities of zinc can be found in soils. When the soils of farmland are polluted with zinc, animals will absorb concentrations that are damaging to their health. Water-soluble zinc that is located in soils can contaminate groundwater. On zinc-rich soils only a limited number of plants has a chance of survival. That is why there is not much plant diversity near zinc-disposing factories. Due to the effects upon plants zinc is a serious threat to the productions of farmlands. Despite of this zinc-containing manures are still applied. Finally, zinc can interrupt the activity in soils, as it negatively influences the activity of microorganisms and earthworms. The breakdown of organic matter may seriously slow down because of this.

2.5 Advantages of Adsorption

- More effective.
- Less expensive.
- Ease to handle high volume.
- Capacity to handle even low metal concentration.
- Feasible alternative for removing heavy metal from effluents.

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2.6 BANANA FIBRE

2.6.1 Introduction

After India and Ecuador, Brazil is the third largest producer of banana. The country has studied this fiber extensively from various standpoints. The most cultivated species in Brazil is *Musa cavendishi*, ‘‘nanica’’ variety. In Brazil, the banana plant has a 3–9 m long stem with a diameter between 200 and 370 mm. This stem (Fig. 1a) consists of different layers containing longitudinal fibers (of about 24% pseudo stem). Fig. 1b shows the leaf sheaths, taken out of these layers, from which the fibers are extracted. The pseudo stem is thrown after harvest and is used for solid mulching; it is used not only by the artisans but also as energy source and other industrial uses.



Fig: 2.1 Banana Stem

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Hence, there is a great opportunity for extending the use of this large source in the country. Ninety-five thousand (9.5 · 10⁴) tons of fiber per annum are produced by the state of Sa˜o Paulo, the main producer in Brazil, compared to a yield of about 3 · 10⁵ tons of fiber in 1.5 million acres of land in India. During the last five years or so, the banana culture has disseminated to other parts of the country. This is attributed to the effort of researchers in the Northeast and Southeast towards the development of new technologies based on renewable resources in the automotive sector. Banana fibers are extracted manually from the pseudo stems using a low cost fiber extraction process; the average fiber yield is 1–2% only on dry basis. In recent times, a mechanical decorticator has been developed for the extraction of fibers such as curaua. By this method, the fiber yield reported is about 1.75 kg on dry weight basis per man-hour, which would put cost of the fiber at US\$ 0.89 per kg.

2.6.2 Extraction of Banana Fibre

Banana fibers were extracted from the stems of banana plant. Longitudinal slices were prepared from stems and fed to fiber extracting machine.

The fiber extracting machine, also known as a mechanical decorticator, consists of a pair of feed rollers and a beater.

The slices were fed to the beater between the squeezing roller and the scrapper roller, following which the pulp gets separated and fibers are extracted and air dried in shade.

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2.6.2.1 Banana fiber extracting machine:

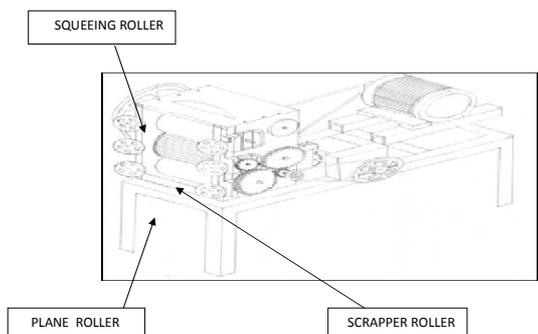


Fig 2.2 Banana fiber extracting machine

2.6.3 Fibre Chemical Treatment:

Banana fibers were immersed in 6% NaOH solution for 2 h at room temperature. After the alkaline treatment, the fibers were thoroughly washed by immersion in water tanks, followed by running water. The material is then filtered and dried at 80°C for 24 h.

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2.6.4 Banana Fiber Properties:

Table 2.3: Physical-Chemical and Mechanical Properties of four varieties of banana fiber

S.No.	Properties	Poovan	Kadhali	Mondhan	Rasthali
1	Physical:				
	a) Moisture regain (%)	9.59	10.15	9.89	11.25
	b) Density (gm ⁻¹)	0.67	0.39	0.5	0.44
	c) Linear	10.15	11.61	11.61	7.39
2	Chemical(%):				
	a) Cellulose	59.55	63	62	55.31
	b) HemiCellulose	28.09	22.6	26	34.04
	c) Lignin	12.36	13	11	10.63
3	Mechanical:				
	a) Modulus (gf/den)	1554.56	1917.46	1918.13	1903.46
	b) Stress (MPa)	0.21	0.3	0.2	0.3
	c) Strain (%)	2.32	1.84	1.51	2.2
	d) Tenacity (gf/den)	20.46	26.77	21.19	41.89

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Table 2.4: Physical-chemical and Mechanical properties of four Banana varieties after Softening treatment

S.No.	Properties	Poovan	Kadhali	Mondhan	Rasthali
1	Physical:				
	a) Moisture regain (%)	11.11	11.54	11.11	13.21
	b) Density (gm ⁻¹)	0.83	1.04	1.00	0.69
	c) Linear Density (den)	9.4	6.7	9.54	5.4
2	Chemical (%):				
	a) Cellulose	80	72.92	75.51	83.02
	b) HemiCellulose	10	14.58	14.28	7.54
	c) Lignin	10	12	10	9.43
3	Mechanical:				
	a) Modulus (gf/den)	2484.49	2405.51	2129.06	3293.16
	b) Stress (MPa)	0.31	0.39	0.38	0.26
	c) Strain (%)	2.88	2.22	1.78	2.62
	d) Tenacity (gf/den)	31.38	28.23	33.16	48.66

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2.8.2 Fiber Preparation

Staple fibers are shipped to the manufacturer in the form of bales and fiber preparation consists of mechanical and pneumatic processes of handling from the bale to the point where the fiber is introduced into the web-forming machine. The following processes are included in a typical fiber preparation line.

2.8.3 Web Forming Process:

The main objective of carding is to separate small tufts into individual fibers, to begin the process of parallelization and to deliver the fibers in the form of a web. The principle of carding is the mechanical action in which the fibers are held by one surface while the other surface combs the fibers causing individual fiber separation. At its center is a large rotating metallic cylinder covered with card clothing. The card clothing is comprised of needles, wires, or fine metallic teeth embedded in a heavy cloth or in a metallic foundation. The cylinder is partly surrounded by an endless belt of a large number of narrow, cast iron flats positioned along the top of the cylinder. The top of the cylinder may be covered by alternating rollers and stripper rolls in a roller-top card.

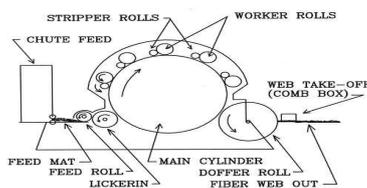


Fig. 2.3:

Basic construction of a card and its parts

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2.7 Material Preparation:

Banana fibers in the form of short non-woven fibers (4-9 mm) were used in this work. The fibers are separated mechanically from banana stalks and then dried in hot air. Then banana fibre which is in short length is combined with cotton to form web using web forming device. As web cannot be formed using banana fibre alone so cotton is used.

2.8 Web Formation:

2.8.1 Introduction

All nonwoven fabrics are based on a fibrous web. The characteristics of the web determine the physical properties of the final product. These characteristics depend largely on the web geometry, which is determined by the mode of web formation. Web geometry includes the predominant fiber direction, whether oriented or random, fiber shape (straight, hooked or curled), the extent of inter-fiber engagement or entanglement, crimp and z-direction compaction. Web characteristics are also influenced by the fiber diameter, fiber length, and web weight, chemical and mechanical properties of the polymer.

The choice of methods for forming webs is determined by fiber length. Initially, the methods for the forming of webs from staple-length fibers were based on the textile carding process, whereas web formation from short fibers was based on papermaking technologies. Though these technologies are still in use, newer methods have been developed.

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The fibers are fed by a chute or hopper and condensed into the form of a lap or batting. This is initially opened into small tufts by a licker-in, which feeds the fibers to the cylinder. The needles of the two opposing surfaces of the cylinder and flats or the rollers are inclined in opposite directions and move at different speeds. The main cylinder moves faster than the flats and, due to the opposing needles and difference in speeds, the fiber clumps are pulled and teased apart. In the roller-top card the separation occurs between the worker roller and the cylinder. The stripping roller strips the larger tufts and deposits them back on the cylinder. The fibers are aligned in the machine direction and form a coherent web below the surface of the needles of the main cylinder.

The web is doffed from the surface of cylinder by a doffer roller and deposited on a moving belt. The orientation ratio of the web at the doffer of a conventional card is approximately 5:1.

2.8.4 Specification of Web:

Banana and Cotton Blend

Length – 0.75 mts

Width – 0.3 mts

Thickness – 8 to 10 mm

Blend ratio % (banana and cotton) – 75:25

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2.9 Needle Punching

2.9.1 Introduction:

Worldwide, the needle punching nonwoven, one of the greatest successes of any textile related process. The needle punching industry around the world is a very exciting and diverse trade involving either natural or both natural and synthetic fibers.

2.9.2 Process:

The needle punch process is illustrated in fig. 1. Needle punched nonwovens are created by mechanically orienting and interlocking the fibers of a spun bonded or carded web. This mechanical interlocking is achieved with thousands of barbed felting needles repeatedly passing into and out of the web.

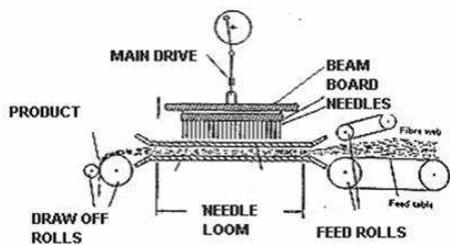


Fig. 2.4: Needle punching process

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2.9.4 The Felting Needle

The correct felting needle can make or break the needle punched product. The proper selection of gauge, barb, point type and blade shape (pinch blade, star blade, conical) can often give the needle puncher the added edge needed in this competitive industry.

The gauge of the needles is defined as the number of needles that can be fitted in a square inch area. Thus finer the needles, higher the gauge of the needles. Coarse fibers and crude products use the lower gauge needles, and fine fibers and delicate fibers use the higher gauge needles. For example, a banana fiber product may use a 12 to 16 gauge needle and fine synthetics may use 25 to 40 gauge needle.

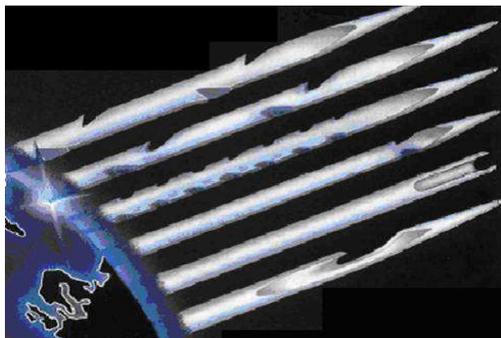


Fig. 2.6: Types of needles

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2.9.3 The Needle Loom:

- The needle board: The needle board is the base unit into which the needles are inserted and held. The needle board then fits into the needle beam that holds the needle board into place.
- The feed roll and exit roll. These are typically driven rolls and they facilitate the web motion as it passes through the needle loom.
- The bed plate and stripper plate. The web passes through two plates, a bed plate on the bottom and a stripper plate on the top. Corresponding holes are located in each plate and it is through these holes the needles pass in and out.
- The bed plate is the surface the fabric passes over which the web passes through the loom. The needles carry bundles of fiber through the bed plate holes. The stripper plate does what the name implies; it strips the fibers from the needle so the material can advance through the needle loom.

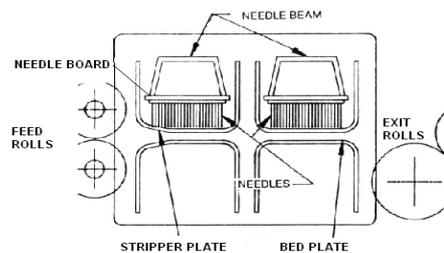


Fig. 2.5: Needle loom

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The major components of the basic felting needle are as follows:

- The crank: The crank is the 90 degree bend on the top of the needle. It seats the needle when inserted into the needle board.
- The shank: The shank is the thickest part of the needle. The shank is that part of the needle that fits directly in the needle board itself.
- The intermediate blade: The intermediate blade is put on fine gauge needles to make them more flexible and somewhat easier to put inside the needle board. This is typically put on 32 gauge needles and finer.
- The blade: The blade is the working part of the needle. The blade is what passes into the web and is where the all-important barbs are placed.
- The barbs: The barbs are the most important part of the needle. It is the barb that carries and interlocks the fibers the shape and sized of the barbs can dramatically affect the needled product.

2.9.5 Needle Penetration:

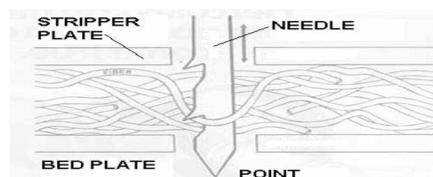


Fig. 2.7: Needle Action – Schematic

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As the needle loom beam moves up and down the blades of the needles penetrate the fiber batting. Barbs on the blade of the needle pick up fibers on the downward movement and carry these fibers the depth of the penetration. The draw roll pulls the batt through the needle loom as the needles reorient the fibers from a predominately horizontal to almost a vertical position. The more needles penetrate the web denser and strong the web becomes generally see fig. 3 beyond some point, fiber damage results from excessive penetration. Thus the principle and mechanism used to produce a needle punched non-woven in banana materials.

2.9.6 Specification of Non-Woven

Needles per depth	– 130 NPI
Thickness	– 8 to 10 mm

2.10 Adsorption Methods

The adsorption of metal ions by banana fibre which is in web form is experimented in two methods.

2.10.1 Method -1

One gram of sample material is weighed (W1) and dipped in 100ml of deionized water that contains 100mg of metal ions (Lead and Zinc). Then continuously stirred the material in deionized water with metal ions for 30 and 60 minutes.

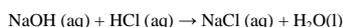
After time reaches, absorbed material is dried in hot air woven. Now the sample material is weighed (W2) again and SS thus comparing W1 and W2 absorption percentage is calculated.

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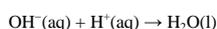
The resulting solution is usually colorless and odorless with slippery feeling upon contact in common with other alkalis.

2.11.1.2 Chemical properties

Sodium hydroxide reacts with protic acids to produce water and the corresponding salts. For example, when sodium hydroxide reacts with hydrochloric acid, sodium chloride is formed:



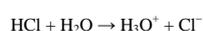
In general, such neutralization reactions are represented by one simple net ionic equation:



This type of reaction with a strong acid releases heat, and hence is exothermic. Such acid-base reactions can also be used for titrations. However, sodium hydroxide is not used as a primary standard because it is hygroscopic and absorbs carbon dioxide from air.

2.11.2 Hydrochloric Acid (HCl)

Hydrochloric Acid(HCl) is a monoprotic acid, which means it can dissociate (i.e., ionize) only once to give up one H^+ ion (a single proton). In aqueous hydrochloric acid, the H^+ joins a water molecule to form a hydronium ion, H_3O^+ .



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2.10.2 Method -2

One gram of sample material is weighed and dipped in 100 ml of deionized water that contains 500mg and 700mg of metal ions (Lead and Zinc). The pH of deionized water is varies from 4, 7 and 9 for different experiments. Then material is continuously stirred in deionized water with metal ions for 30 and 60 minutes.

After the time reaches, absorbed material is taken out from deionized water with metal ions. Now the deionized water with metal ions is tested using Atomic absorption spectroscopy for calculating the amount of metal ions remains in deionized water after dipped with banana fiber.

2.11 Chemicals Used for maintaining pH

- Sodium hydroxide
- Hydrogen chloride

2.11.1 Sodium Hydroxide (NaOH)

2.11.1.1 Physical properties

Pure sodium hydroxide is a whitish solid, sold in pellets, flakes, and granular form, as well as in solution. It is highly soluble in water, with a lower solubility in ethanol and methanol, but is insoluble in ether and other non-polar solvents.

Similar to the hydration of sulfuric acid, dissolution of solid sodium hydroxide in water is a highly exothermic reaction in which a large amount of heat is liberated, posing a threat to safety through the possibility of splashing.

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The other ion formed is Cl^- , the chloride ion. Hydrochloric acid can therefore be used to prepare salts called chlorides, such as sodium chloride. Hydrochloric acid is a strong acid, since it is essentially completely dissociated in water.

Monoprotic acids have one acid dissociation constant, K_a , which indicates the level of dissociation in water. For a strong acid like HCl, the K_a is large. Theoretical attempts to assign a K_a to HCl have been made. When chloride salts such as NaCl are added to aqueous HCl they have practically no effect on pH, indicating that Cl^- is an exceedingly weak conjugate base and that HCl is fully dissociated in aqueous solution. For intermediate to strong solutions of hydrochloric acid, the assumption that H^+ molarity (a unit of concentration) equals HCl molarity is excellent, agreeing to four significant digits. Of the six common strong mineral acids in chemistry, hydrochloric acid is the monoprotic acid least likely to undergo an interfering oxidation-reduction reaction.

It is one of the least hazardous strong acids to handle; despite its acidity, it consists of the non-reactive and non-toxic chloride ion. Intermediate-strength hydrochloric acid solutions are quite stable upon storage, maintaining their concentrations over time. These attributes, plus the fact that it is available as a pure reagent, make hydrochloric acid an excellent acidifying reagent.

Hydrochloric acid is the preferred acid in titration for determining the amount of bases. Strong acid titrants give more precise results due to a more distinct endpoint. Azeotropic or "constant-boiling" hydrochloric acid (roughly 20.2%) can be used as a primary standard in quantitative analysis, although its exact concentration depends on the atmospheric pressure when it is prepared.

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Hydrochloric acid is frequently used in chemical analysis to prepare ("digest") samples for analysis. Concentrated hydrochloric acid dissolves many metals and forms oxidized metal chlorides and hydrogen gas, and it reacts with basic compounds such as calcium carbonate or copper (II) oxide, forming the dissolved chlorides that can be analyzed.

2.12 Calculation

$$Q1 = \frac{(C0 - C1) \times V1}{W}$$

Where,

Q1 – Adsorption capacity mg/g

C0 – Critical concentration

C1 – Residual concentration

V1 – Volume of solution (L)

W – Weight of material before adsorption

2.13 Atomic Adsorption Spectroscopy

2.13.1 Basic Principle:

Atomic Absorption Spectroscopy (AAS) is an analytical technique that measures the concentrations of elements. It makes use of the absorption of light by these elements in order to measure their concentration.

Atomic-absorption spectroscopy quantifies the absorption of ground state atoms in the gaseous state. The atoms absorb ultraviolet or visible light and make

careful selection of wavelength allow the specific quantitative determination of individual elements in the presence of others.

The atom cloud required for atomic absorption measurements is produced by supplying enough thermal energy to the sample to dissociate the chemical compounds into free atoms.

Aspirating a solution of the sample into a flame aligned in the light beam serves this purpose. Under the proper flame conditions, most of the atoms will remain in the ground state form and are capable of absorbing light at the analytical wavelength from a source lamp.

The ease and speed at which precise and accurate determinations can be made with this technique have made atomic absorption one of the most popular methods for the determination of metals.

A third field in atomic spectroscopy is atomic fluorescence. This technique incorporates aspects of both atomic absorption and atomic emission. Like atomic absorption, ground state atoms created in a flame are excited by focusing a beam of light into the atomic vapor. Instead of looking at the amount of light absorbed in the process, however, the emission resulting from the decay of the atoms excited by the source light is measured. The intensity of this fluorescence increases with increasing atom concentration, providing the basis for quantitative determination.

transitions to higher electronic energy levels. The analytic concentration is determined from the amount of absorption

Concentration measurements are usually determined from a working curve after calibrating the instrument with standards of known concentration. Atomic absorption is a very common technique for detecting metals and metalloids in environmental samples.

The image shows a periodic table where elements detectable by atomic absorption are highlighted in pink. These elements include: Li, Be, B, C, N, O, F, Ne; Na, Mg, Al, Si, P, S, Cl, Ar; K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr; Rb, Sr, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Xe; Cs, Ba, La, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl, Pb, Bi, Po, At, Rn; and Fr, Ra, Ac.

Fig 2.8 Elements detectable by atomic absorption are highlighted in pink in this periodic table

2.13.2 Atomic Absorption Process

The quantity of interest in atomic absorption measurements is the amount of light at the resonant wavelength which is absorbed as the light passes through a cloud of atoms. As the number of atoms in the light path increases, the amount of light absorbed increases in a predictable way. By measuring the amount of light absorbed, a quantitative determination of the amount of analyzed element present can be made. The use of special light sources and

2.13.3 Atomic Absorption Spectrophotometer



Fig 2.9 Atomic absorption spectrophotometer

2.13.4 Light Source

The light source is usually a hollow cathode lamp of the element that is being measured. It contains a tungsten anode and a hollow cylindrical cathode made of the element to be determined. These are sealed in a glass tube filled with an inert gas (neon or argon). Each element has its own unique lamp which must be used for that analysis.

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials:

22 denier banana fibre and 5 denier cotton, banana/cotton (75/25) blended fibre were used for the preparation of needle punched fabrics. The properties of the fibers are given in table.

Table 3.1: Properties of fibers:

Properties Fibres	Diameter (u)	Length (Cm)	Actual linear density (denier)	Tenacity (g/tex)	Elongation (%)
BANANA FIBRE	25.28	3	22	54.92	3.33
COTTON FIBRE	6.20	2	5	8.3	4.1

3.1.1 Chemicals

Sodium hydroxide is purchased from m/s The Precision Scientific Co., Coimbatore. Hydrochloric acid, Zinc oxide and Lead phosphate is obtained from Ranbaxy. All chemicals are of laboratory grade and there is no need of further purification.

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The tenacity and elongation were measured in machine direction using instron tester for testing tenacity, breaking elongation the sample size and rate of straining were chosen according to ASTM standard D 1117-80.

The air permeability was tested on the testo crafts air permeability tester and the testing was carried out as per ASTM standard D 737-75. The test area was 5 .07cm² as 1 inch diameter circle was exposed. When the specimen was clamped in the holder. The 10 inch * 10 inch specimen was clamped on the holder in such a way that the area exposed to test was sufficiently away from the edges in order to avoid the edge leakage. 10 readings were taken for each sample and the average calculated.

Shirley stiffness tester was used for measuring the bending length as per BS: 3356. Specimens were cut to the size of the template in both machine and cross direction and then both template and specimen were transferred to the plate form with the fabric underneath. Both were slowly pushed forward. The strip of the fabric will commence to drop over the edge of the platform and the movement of the template and fabric was continued until the tip of the specimen viewed in the mirror cuts both index lines. The bending length was read from the scale. Four specimens were tested for each sample in both machine and cross directions each, and each specimen was tested four times at both ends alternatively top and bottom. The average values of bending length for machine direction and the cross direction were calculated.

Martindale abrasion tester was used for measuring the abrasion resistance. (Weight loss in milligram) as per ASTM standard D 4886-88. The pore sizes of the fabric were measured by hydrometer method, which is based on stoke's equation for velocity of a free falling sphere.

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3.2 Methods

3.2.1 Softening:

Banana fiber is stiff and rigid by nature because of the cellulosic structure and arrangement of that fiber. Because of this reason the applications of the banana fiber should be restricted. So to make a soft and flexible fiber is the important process for use this in various applications.

For softening the fibers were taken in a bath containing 10% of NaOH. It was heated at 40°C to 50°C for 60 min. Finally the fibers were washed thoroughly with hot water followed by cold water. Then sprayed (treated) with mixing of batching oil (1 lit) and water (9 lit) in room temperature for 24 hrs in easy processing.

3.2.2 Sample Preparation

Needle-punched fabrics were made from parallel laid webs, the parallel laid webs were produced using a laboratory carding machine. Then the webs were punched on DILLO needle loom, od-11 /6, cbf/6 lab model machine using 15*18*32*3.5 cb needle board with the following specification

1. Number of needles/1mts working width = 8000 to 10000
2. Stoke frequency = max 1200/min
3. Production speed = max 10 m/min

3.2.3 Fabric Testing:

The needle-punched fabric was tested for tenacity, elongation at break air permeability, abrasion resistance bending length. All tests were carried out in the standard atmosphere of 65 - 2% RH and 20 -2°C.

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3.2.4 Adsorption Experiment

1g banana fiber needle felted fabric was immersed in 250ml of deionized water containing 500 and 700 mg/L of Pb²⁺, Zn²⁺ under room temperature. The solution was stirred for 5 minutes and then kept for 1 hour. Finally, the solution was filtered and the residual Pb²⁺ and Zn²⁺ concentration of the filtrate was measured by using atomic adsorption spectrometry (AAS). The Pb²⁺ and Zn²⁺ adsorption capacity of the material is calculated according to equation 1.

$$q_{max} = \frac{(C_0 - C_1) \times V}{m}$$

Where

q_{max} is Pb²⁺ or Zn²⁺ adsorption capacity of the fabric (mg/g),

C_0 is the initial Pb²⁺ or Zn²⁺ concentration (mg/L),

C_1 is the residual Pb²⁺ or Zn²⁺ concentration after adsorption (mg/L),

V is the volume of solution (L),

m is the weight of fabric before adsorption (g)

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4.1 Fabric Properties

The developed 75:25 Banana/Cotton fiber blended non woven fabric has the following property

1. Tenacity - 0.98 gm/tex
2. Breaking elongation -35.1 %
3. Air permeability -107.2 cm³/cm²/sec
4. Bending length
 - Machine direction -4.2 cm
 - Cross direction -5.1cm
5. Thickness -7.8 mm
6. Fabric weight - 400gms/sq mts
7. Abrasion resistance -66 mg (weight loss)
8. Pore size -30 microns

Table 4.1: Lead Adsorption

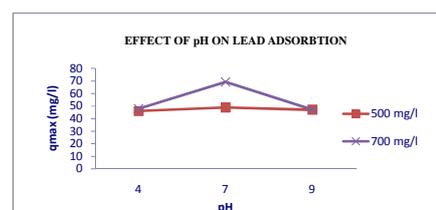
S.NO	MEAN (ppm)	SD	RSD	q _{max} mg/gm
1	10.975	0.0478	0.4	48.9
2	7.648	0.0462	0.6	69.23
3	10.661	1.960	18.4	48.93
4	0.998	0.1371	13.7	69.90
5	4.525	0.0552	1.2	49.54
6	18.865	0.686	0.4	68.11
7	31.689	0.4789	1.5	46.83
8	27.480	0.1986	0.7	67.252
9	38.776	5.27	14.3	46.122
10	21.990	2.786	12.7	47.80
11	28.801	0.1237	0.4	47.12
12	27.758	0.1736	0.6	47.224

Table 4.2: Zinc Adsorption

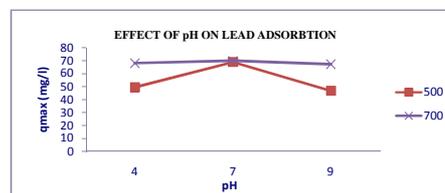
S.NO	MEAN (ppm)	SD	RSD	q _{max} mg/gm
1	21.003	0.1586	0.8	47.89
2	22.722	0.2103	0.9	67.72
3	22.429	0.1908	0.9	47.75
4	22.063	0.1925	0.9	67.79
5	22.787	0.3583	1.6	47.72
6	23.395	0.2176	0.9	67.66
7	23.009	0.5869	2.6	47.69
8	23.611	0.2422	1.0	67.63
9	22.256	0.2616	1.2	47.77
10	19.746	0.2115	1.1	68.02
11	20.38	0.2625	1.3	47.96
12	19.906	0.4302	2.2	68.01

4.3 Effect of pH on Adsorption Capacity

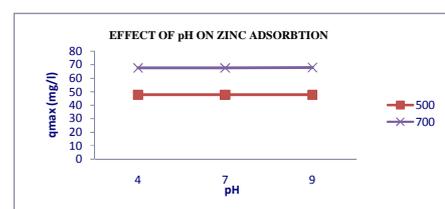
Lead Concentration-500, 700, Time-30mins:



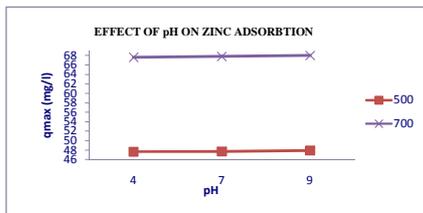
Lead Concentration-500, 700, Time-60mins



Zinc Cc-500, 700, Time-30mins



Zinc Cc-500, 700, Time-60mins



Batch studies were conducted by contacting banana fibre material with approximately 500 and 700 mg/L Lead solution with Initial pH values of 4.0, 7.0 and 9.0. After 30 min the pH was measured and it was found that the variation between the initial pH and final pH for the studies was less than 5 percent.

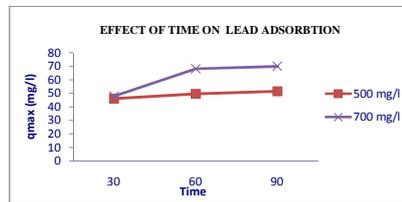
The adsorption of lead to banana fibre can be explained on the basis of the constituent of banana fibre. The major constituent of banana fibre are lignin and cellulose which have polar functional groups that are particularly effective in bonding trace elements such as lead and zinc. Lignin is a polymeric substance which has hydroxyl groups that can exert repulsive force on the approaching anion thereby aiding adsorption of lead to banana fibre.

The effect of pH on metal ion adsorption by banana fibre needle felted fabric was investigated and the results are presented in Figures A. and B. The initial pH of the metal ion solutions were changed as 4,7 and 9. Adsorption of metal ions increases with an increase in pH where the charge of surface decreases also within the studied pH range, the best adsorption was obtained at pH values close to 7.

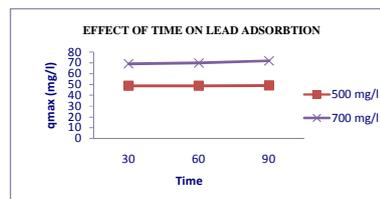
At low pH values adsorption is low where surfaces have strong positive charge similar to that of the ions. However there is still adsorption even though there is an repulsion between surfaces and metal ions. This might indicate a limited contribution of chemical adsorption that is caused by the unpaired electrons of nitrogen at functional groups of banana fibre

4.4 Effect of Contact Time

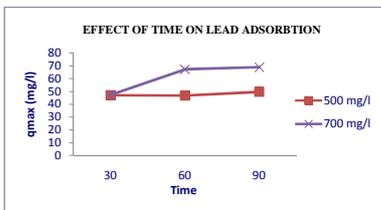
Lead pH-4



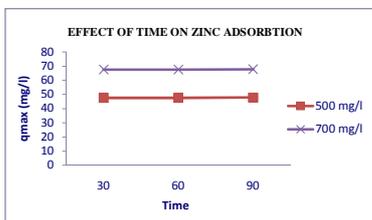
Lead pH-7



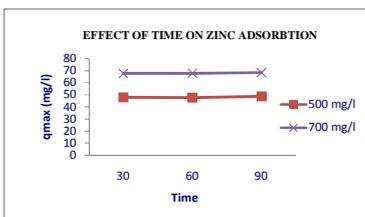
Lead Ph-9



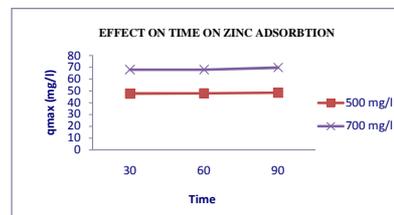
Zinc pH-4



Zinc pH-7



Zinc pH-9



Contact time is an important parameter because this factor determines the adsorption kinetics of an adsorbate at a given initial concentration of the adsorbate. The effect of contact time on the heavy metal ions adsorption by banana fibre needle felted fabric was investigated for 30, 60 and 90 min. The kinetic studies were carried out for different initial concentrations 500 and 700 mg/L for Pb2+ and Zn2+ ions on banana fibre needle felted fabric at 298.15 K.

4.4.1 Lead (Pb2+) and Zinc (Zn2+)

Figures A show the effect of contact time, concentration on adsorption of Pb2+ and Zn2+ ions on banana fibre needle felted fabric. In Figures A it was observed that Pb2+ ions is gradually adsorbed and nearly 60 and 90 minutes are enough to reach equilibrium for banana fibre needle felted fabric at 298.15. The uptake of Pb2+ is increasing with temperature and pH of the solution. Increasing the uptake amount of Pb2+ with temperature show the endothermic nature of adsorption process.

CHAPTER-5
CONCLUSION

- Adsorption studies were performed to investigate the adsorption capacity of banana fibre needle felted fabric toward heavy metal ions (Pb²⁺, and Zn²⁺) under different conditions such as pH, contact time, concentration.
- The amount of Pb²⁺, and Zn²⁺ adsorbed was found to vary with the initial solution pH, adsorbent dosage, contact time, and concentration.
- The amount of Pb²⁺, and Zn²⁺ ions uptake (mg/g) was found to increase in solution pH, concentration and contact time.
- The maximum amount of Pb²⁺, and Zn²⁺ ions uptake at 298.15 K were 69.9 and 68.02 (mg/g) banana fibre needle felted fabric.
- By experiment we have found that adsorption of lead and zinc is high at pH 7 irrelevant of time and concentration.
- The addition of chemicals (NaOH, HCl) to change pH of the aqueous solution is the reason for low adsorption at other pH levels.
- The adsorption method of extracting metal ions from aqueous solution is the best when we compare the parameters of cost, efficiency and pollution with conventional methods like Reverse osmosis, carbonization and Dumping.

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CHAPTER 7
REFERENCE

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CHAPTER-6
SCOPE OF STUDY

- To modify the fibre surfaces with chemicals for an enhancing the adsorption characteristics.
- To investigate the metal ion adsorption in industrial effluent load.
- To study the disposal of used sorbent in metal ion adsorption.

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