SUSTAINABLE SOLUTIONS IN MATERIALS SCIENCE: WATER TREATMENT, WASTE MANAGEMENT AND CONSTRUCTION INNOVATIONS

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PREFACE

In an era of rapid urbanization and environmental challenges, the need for innovative solutions in both construction and environmental management has never been more urgent. This book, **"Sustainable Solutions in Materials Science: Water Treatment, Waste Management, and Construction Innovations"** delves into four significant areas of research and application, each contributing to the advancement of sustainable practices in their respective fields.

The first section explores, offering a cutting-edge approach to addressing one of the most critical environmental issues of our time—water pollution. The utilization of nanotechnology in water purification holds great promise for mitigating the harmful effects of industrial waste on our ecosystems.

In the second section, we turn our attention to section used in construction, specifically in Ilaro Township, Ogun State, Nigeria. Sandcrete remains a key building material in many developing regions, and understanding its properties is essential to improving the safety, durability, and efficiency of construction practices.

The third section highlights, as the world grapples with the growing problem of plastic pollution, PHAs provide a sustainable alternative for creating biodegradable plastics, which could play a pivotal role in reducing environmental waste.

Finally, the book explores the last section for water purification. With clean water being an increasingly scarce resource, the ability to effectively purify water using advanced filtration technologies is critical for both human consumption and environmental conservation.

Each of these topics represents a piece of the puzzle in building a more sustainable and resilient future. The research presented in this book offers new insights and practical solutions that can be applied across various industries and communities.

I commend the authors and contributors for their dedication to addressing some of the most pressing challenges of our time. Through this book, we are reminded that the path to sustainability is paved with innovation, collaboration, and an unwavering commitment to improving the world for future generations.

Dr. Ethem İlhan ŞAHİN

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CHAPTER 1

ADSORPTION OF LEAD FROM WASTE WATER BY NANO COMPOSITE MATERIALS FOR ENVIRONMENT MANAGEMENT

Dr. Rajeev Arora

1. INTRODUCTION

The lead and tin industry [1] pollutes the environment in mechanical engineering manufacturing processes. These materials also affect the ground and surface aqueous system, especially lead [2]. Lead (Pb), mercury (Hg), Cadmium (Cd), Zinc (Zn), Chromium (Cr), Copper (Cu), and Nickel (Ni) are under the category of hazardous and toxic materials [3]. The metabolism process of human beings is affected by the lead present in the food system [4] and the aqueous system [5]. Researchers search for new technologies [6] to remove hazardous materials from industrial wastewater and groundwater. The dangerous material lead is commonly used for battery industries [7], bangles, the crockery industry as building materials, etc. Scientists have used different types of nanocomposite material [8], waste composite, industrial waste materials, and metal oxides for the adsorption of lead from the water system. Conducting polymers is a vital application in which Polypyrrole and Polyaniline are essential. Nano polyaniline composite membrane [9] removed 100% efficient lead ions from water systems. This study aimed to find an efficient nanocomposite material or nanomaterials for lead adsorption from aqueous systems.

2. Materials used for the removal of heavy metals from the aqueous system

2.1 Heavy metal removal by polymer/conducting polymer

It is observed that the nitrogenous site (NH-) of the conducting polymer polyaniline adsorbs the heavy metal lead. Banana peel-polyaniline composite [10] adsorbs the 57.24% lead from industrial wastewater. The cellulose [11], lipids, simple sugars, starch, carbohydrates, and lignin represent too high a potential to absorb heavy metals. Second-order kinetics was observed during the adsorption process of lead by the composite formed of conducting polymer polyaniline and lanthanum metal [12]. Wang [13] discussed the sorbent of lead ion electrochemically by the composite created polyaniline and graphene oxide composite. Nanocomposites of polyaniline and Nickel were developed by Bhaumik [14], who observed that at an average temperature of 25 ^{0}C, the adsorption of PB (II). The quantity was adsorbed 414.67 mg per gm nanocomposite adsorbent. Fe_3O_4/polyaniline nanocomposite was prepared by Sadeghi [15], and found the surface area of Fe_3O_4, 111.11m^2/gm modify with polyaniline. It also offered the second-order kinetic model for nanocomposite materials for the adsorption of lead (II).

2.2 Zeolite and coal fly ash for Lead Adsorption

Oxygen ions O_2- as negatively charged ion for the zeolite composite material with coal ash material adsorbed the positively charged ion (Pb^{2+}) from wastewater. The modified zeolite was by iron

(III) oxide or hydroxide by Pornsawai [16]. Manganese oxide coated with coal fly ash [17] is used for the adsorption process of the lead ion with a maximum adsorption capacity of 141 mg/g at a temperature of 40^0C. 146 to 165 mg Pb (II) [18] adsorbed by the modified coal fly ash using farmland soil. With this view, it was observed that Coal fly ash could be utilized for wastewater treatment [19]. Pb (II) ion adsorbed by the vacant sites available on the surface of modified fly ash with TiO_2 at low metal ion concentrations [20].

2.3 Heavy metal leads removal by TiO_2

TiO_2, in different forms, photo catalyst, anatase, and rutlie, is non-toxic, low cost, has a high affinity to metal ions, and has high chemical stability used for wastewater treatment purposes as heavy metal lead adsorption purposes. The researchers used nano TiO_2-based nanocomposite to adsorb heavy metals Pb^{2+}, $Cd^{2+,}$ Cu^{2+}, and Hg^{2+} [21]. The researchers also observe the parameters that affect the adsorption process of lead ion pH, temperature, initial metal concentration, contact time, adsorbent dose, and initial metal concentration.

2.4 Tin Oxide for heavy metal adsorption

Tin oxide is a non-toxic and stable material. It is used for lead and cadmium adsorbent from aqueous system [22]. Tin Oxide (SnO_2) nanoparticles [23] are modified with silica and triethoxysilane for heavy metal adsorption from the aqueous system.

2.5 Chitosan nano adsorbents for heavy metal removal

Chitosan is a biopolymer formed from an alkaline deacetylated derivative of chitin. Chitosan comprises good chelation behavior, biological, excellent oxidation-reduction potential, high reactivity, non-toxicity, and high pollutant affinity [24].

Chitosan-based nano adsorbents and their chemical structure modifications, such as grafted Chitosan cross-linked Chitosan, for heavy metal adsorption from the water environment. Chitosan is a biopolymer formed from the alkaline deacetylated derivative of chitin. Chitosan comprises good chelation behavior, biological, outstanding oxidation-reduction potential, high reactivity, non-toxicity, and high pollutant affinity [24]. Chitosan-based nano adsorbents and their chemical structure modifications, such as grafted Chitosan cross-linked Chitosan, for heavy metal adsorption from the water environment.

2.6 Different metal oxide for the adsorption of heavy metals

Mixed metal oxides such as zirconium and graphene oxide [25] have higher adsorption capacity of heavy metals from the wastewater. As CuAl-, MgAl-and CoAl-MMOs with graphene oxide (GO) are used for the adsorption of heavy thiophenes from the compounds. Liu has used the Aluminum and magnesium-based composite material for the adsorption of Cr (VI) and Cu^{2+} [26].

3. Parameters affected the Lead adsorption Process

3.1 pH of Industrial waste water

The conducting polymer Polyaniline, Polypyrrole, mixed metal oxide, zinc oxide, coal fly ash, rice husk ash, zinc oxide, titanium dioxide, and mixed metal oxide have been used to adsorb the heavy metals from industrial wastewater within the range of pH 2 to 8 [27]. Scientists observe that at high pH values, more heavy metals will be adsorbed [28]. Heavy metal adsorption from wastewater systems is found between the pH values 6-8 by the conducting polymeric materials [29]. Ramaya [30] observed that the pH was 2.0 for the Cr (VI) at room temperature.

3.2 Contact time

The different parameters affect the adsorption process, as contact time [31] is essential. Polyaniline [32] based nanocomposite was used for the dye adsorption process. The adsorption process of heavy metal by the nanocomposite material based on polyaniline [33] required less contact time. The properties of the adsorbate affect the adsorption process of dye and heavy metals from the aqueous system. Under different processing conditions, mass transfer [34] resistance affects the contact time for the adsorption process.

3.3 Process effect on adsorption

Different processes have been implemented for maximum adsorptions of heavy metals from industrial wastewater: packed bed column [35], fluidized bed [36] process, and fixed batch [37] process. This process gives the idea for parameters affecting adsorption, such as feed concentration [38], rate-limiting steps [39], an adsorbent mass [40], and bed depths [41].

4. Types of nanomaterials and their composite used for Lead heavy materials from aqueous system

Table1. Nanomaterials and its composite are used as an Adsorbent

Sr. No.	Nano Materials and Its Composite	Adsorbed Material Lead	Reference
1	Si/Al		[42]
2	Ultrasmall super paramagnetic magnetite nanoparticles (USMNs)	Adsorbent amount= 315.43 mg/gm	[43]
3	Chitosan Nanoparticles (N-Vh-Sal)	Adsorbent amount=123.67 g/gm	[44]
4	Nano Porous Zeolite	Adsorption amount=93 mg/gm	[45]
5	Tergitol @SiO_2@Fe_3O_4	Adsorbent amount=41.5 mg	[46]

		Adsorbent Time=11.5 min pH=4.7	
6	Bio-compatible nano adsorbents	pH=5.0	[47]
7	Zirconium Silicate	Adsorption amount = 1.4mmol/gm pH=7.0	[48]
7	Lignin-grafted Nanotubes	Distribution coefficient for lead(K_d) =3.6x10^5 ml/g Adsorption amount=235 mg/gm	[49]
9	Nano metallothionein	Adsorption amount = 325mg/gm pH=3 Time of contact=5 min	[50]
10	Modify Sodium/bentonite	Adsorbent dosage =0.2 gm pH=5 Adsorbent	[51]

		time=120 min	
11	Nanoparticles coated Zirconia	Adsorption amount =117.67 mg/gm pH=7±0.2 Time of contact=360 min	[52]
12	Nano iron sulfide composites	Adsorption amount = 98.04 mg/gm	[53]
14	Large Pore Diameter nano adsorbent/Organic ligand onto the mesoporous silica	Adsorption amount= 169.34 mg/gm	[54]
15	Iron oxide/hydroxide (α,γ-FeOOH) nanoparticles	Adsorption amount= 5mg/L pH = 5.2	[55]

5. CONCLUSIONS

Lead Heavy metals can be adsorbed by industrial wastewater using the nanomaterials composite. Nanocomposite materials may be based on conducting polymer polyaniline/Polypyrrole, metal oxide composite, and biocomposite material. In the aqueous system, the problem of aggregation of nanomaterials can be solved by developing its composite by in-situ or ex-situ techniques. Nanocomposite, biocomposite, and waste composite materials are better adsorbents in the following terms: pH value, contact time, kinetics, and processing in less time. It is also observed that energy consumption and operating costs are lesser using nanocomposite, biowaste, and biocomposite material in the adsorption reactor, i.e., packed bed, continuous or batch column. Therefore, we need to generate new nanocomposite material based on waste material.

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CHAPTER 2

MECHANICAL PROPERTIES OF SANDCRETE BLOCKS (SCBS) USED FOR BUILDING CONSTRUCTION IN ILARO TOWNSHIP OF OGUN STATE, NIGERIA

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1. INTRODUCTION

The need for safe and affordable housing for citizens cannot be overemphasized [1]. The resilience of a structure is primarily determined by the quality of materials that were utilised in its making [2]. Sandcrete Blocks (SCB) is a vital material used for building in Nigeria. The popularity and widespread use of SCB as wall material in the country and other emerging countries cannot be overstated [3]. Sand-concrete blocks are the main wall material used in the construction of buildings [1]. SCB are composite building materials that are mainly used to build both load-bearing and non-load-bearing walls. This situation requires that the SCB be manufactured to have the ultimate and required strength. SCB are made by properly mixing fine aggregate (sand) with cement and water in an appropriate proportion (SCB are composite structures). For over 50 years, block manufactured in West Africa has made broad use of sand beds as a common construction material. In every nation, block casting or sandcrete technology is progressively serving as the base for infrastructure development [4].

When properly manufactured, SCB must conform to BS 2028 (1968) suggestions for structural masonry's density and compressive strength [5]. SCB consist of water, sand and cement. Sand and concrete blocks are building elements used in the construction of vertical components of a structure, that is, walls and partitions. Sand and concrete blocks of different sizes are used to build independent walls and structures with capacity to bear loads and as partitions with non-load-bearing capacity [6]. [7] stated that sand and concrete blocks are the most common and popular masonry wall elements in Nigeria. Building constructions having load-bearing and non-load-bearing components, as well as freestanding walls are popular in Nigeria because they are inexpensive and simple to build with SCB [2]. SCB are at times used to give buildings aesthetics and to control moisture penetration and wind effects. This benefit of sandblasted concrete compared to its cost and adaptation to climatic conditions is the reason for its widespread use, specifically in small and medium-sized constructions in nations with tropical rainforests, where significant amounts of rain and high mean temperatures prevail [8]. Many countries around the world, including Nigeria have been using SCB in the construction industry. The material ingredients, their mixing, the presence of additives, and the production procedure are significant factors that govern the characteristics of SCB [9].

Many structural failures and building collapses occur around the world. According to [4], sand-concrete blocks, an important building material, may undoubtedly be related to some of these problems within the construction industry. It was also found that the collapse of a building does not depend on the size of the structure [10]. The primary issue with the production of SCB is that the majority of the SCB made by the block industries did not reach the necessary level for compressive strength [8]. The compressive strength of most SCB produced and used in construction is lower than the values recommended by the Nigerian Industry Standard (NIS), which is 2.5 N/mm^2 for machine compacted blocks and 2.0 N/mm^2 for manually compacted blocks [4]. Studies by various researchers [11, 12, 13, 14] have shown that many SCB manufactured commercially in different parts of Nigeria do not meet the compressive strength requirements of [15].

The constituents of SCB are cement, fine aggregate (sand) and water. After mixing the constituents, they can be moulded into diverse sizes and shapes [16]. Sandcrete is different from concrete as regards to its material composition, because the Sandcrete mix does not have coarse aggregate [17] (Anya, 2015). Sandcrete is different from mortar because it has zero sedimentation [18]. As in other parts of the world, SCB are extensively used in West African nations including Nigeria for load-bearing or non-load-bearing walls of buildings. The sizes and shapes of SCBs in Nigeria are 225 x 225 x 450mm hollow blocks, 150 x 225 x 450mm hollow blocks, 125 x 225 x 450 mm solid blocks and 125 x 150 x 450mm solid blocks [17]. The NIS define SCB "as a composite material of cement, sand and water molded into various sizes". The blocks are bound together with mortar to form walls [18].

In the effort to improve production practices and use of best materials, the Nigerian Standards Organization (SON) developed an informative document in 2000 specifying minimum requirements and usage for various types of SCB (NIS, 2000). The SCB Standard 2007 has become the standard reference text for SCB manufacturing in Nigeria [12]. SCB are structural or non-structural units usually made of plain Portland cement, sharp sand from rivers, water from rivers, and wells, mixed in proper proportions and moulded into various desired sizes. The production process of SCBs involves several stages, which include: batch making, mixing of materials (cement, sand and water), the molds are filled with the mixed materials, and compacted followed by demoulding and finally, curing of SCBs.

SCBs were examined in the Minna, Bosso and Shiroro towns of Niger State, Nigeria the strength properties of SCB [11]. Compressive strength and sieve analysis tests were performed on the blocks and soil samples respectively. The test results showed that the aggregates used are suitable for the production of blocks. The compressive strength of SCB were not up to the standard prescribed by NIS 87:2000. Individual block compressive strengths ranged from 0.11 N/mm^2 to 0.75 N/mm^2, and average block compressive strengths ranged from 0.14N/mm2 to 0.66N/mm^2. In order to improve the quality of SCB, proper curing and proper selection of production materials have been recommended. In the reports of the compressive strengths and statistical properties of SCB collected from 25 different block factories in Ondo State, Nigeria [18], the results showed that the average strength of the 150 x 225 x 450mm and 225 x 225 x 450mm SCBs were 0.55N/mm^2 and 0.45N/mm^2respectively. They discovered that the values were less than what the corresponding codes and standards requirement. The compressive strength of these blocks followed a normal distribution, according to statistical analysis, however the overall coefficient of variation was 0.71 and 0.54 for the 225 x 225 x 450mm blocks and 150 x 225 x 450mm blocks respectively. They came to the conclusion that because the values were high, the manufacturing processes' quality control was noticeably lacking. Recommendations were provided to increase the strength and effectiveness of SCB manufacturing in light of the observed inadequate quality control.

The compressive strength characteristics of SCB made in Calabar city were examined [20]. They visited ten (10) block-shaped sites, and twelve (12) SCB were randomly chosen from each site and dried for 3, 7, 14,and 28 days. They also collected the aggregates used to form the blocks and the sizes of their particles. From the findings, the 28-day compressive strength of SCB made in the Calabar block industries ranges from 0.23N/mm^2 to 0.58N/mm^2. These values are lower than the least benchmark of the Nigerian National Building Code (2006) for individual blocks and 2.0N/mm^2 for non-load-bearing walls in accordance with British Standard. The effect of suppliers' quality control procedures on the caliber of blocks made in Ghana's capital city of Kumasi was examined by [21]. They examined the compressive strength, bulk density, water absorption, and dimensional tolerances of SCBs that we purchased from vendors. Additionally, samples of fine aggregate were obtained from the suppliers and examined for grading, silt concentration, and organic matter content. The quality of SCB was found to be influenced by the ratio, quality, and mixing of components, as proven by the study. Some contractor personnel, lacking formal quality control training, used the appearances rather than laboratory testing to assume quality. The mix ratios used ranged from lean 1:8 to weak 1:19 (cement: sand). It was also found that the manufactured blocks are not suitable as load-bearing walls.

The purpose of this paper is to investigate the compressive strength of SCB from different sources in Ilaro town of Ogun State. The study will check the mechanical properties of SCBs frequently used in construction sites in ilaro, which will include the determination of the compressive strength, modulus of elasticity, shear modulus and tensile strength of the SCB. Ilaro (6.8054^{0}N, 3.0126^{0}E) is a town in Ogun State, Nigeria. It is the headquarters of Yewa South

Local Government. The city of Ilaro is a developing city with a population of about 57.850 people.

2. Materials and Methods

The drive of the study is to determine the mechanical properties of several selected sand-concrete hollow blocks marketed for construction in Ilaro township of Ogun State, Nigeria. SCB samples for testing were obtained from three commercial block production factories in Ogun State; Most of the manufactured hollow SCBs are of two types. These are 6-inch and 9-inch hollow blocks with standard dimensions of 150 x 225 x 450mm and 225 x 225 x 450mm respectively. They are made by hand using moulds and machines. Both hand-moulded and machine-vibrated blocks were made from a controlled blend of high-quality materials. This study uses the 9-inch hollow blocks. SCB were produced from a mixture of cement, fine aggregate (sand) and water based on field observations. Ordinary Portland cement was used as cement, while fine aggregate was mostly sharp river sand, and the main water source was from water well or borehole.

The cluster sampling technique was used to select the sand and concrete blocks. In cluster sampling, the population is divided into sections, among whom samples were selected. An advantage of the random sampling method is that accuracy is not necessarily lost if less than the entire population is observed. This saves manpower, computing time, and cost. Three (3) block factories designated as A, B and C were randomly selected and visited in different areas of the town, and twenty (20) samples of 9-inch (225 x 225 x 450mm) SCB were bought from each industry. The samples were labeled accordingly to distinguish them. The samples were exposed to laboratory tests to ensure water absorption and compressive strength.

These samples were selected from finished blocks ready to be delivered to end users. In addition, water samples were taken for analysis to ensure their transferability. A visit to the block industry showed that during the production process, all block industries used machines to compact or vibrate the blocks, while most distributed the materials by volume using carts. However, some industries do not have a unique measurement system for group distribution, as observed in most of the blocks visited. In most cases, they create a sharp pile of sand using an eye gauge and add cement to it according to the National Building Regulations (2006) and NIS 87:2007 standard mixing ratio of 1:6. Some workers stated that, with years of experience, volume sorting always slows down the production process, so they prefer the visual metric. The blocks were molded and dried with a spray of water 24 hours after moulding. Treatment continues for at least 3 days before the manufacturers sell them to end users.

The tests undertaken on the purchased SCB were degree of water absorption, compressive strength test, and sieve analysis on fine aggregates picked from the three selected manufacturers of SCB in Ilaro, as required by the specifications of NIS 87:2007 and the National Building Code (2006) for the analysis and control of the quality of SCB. To further enrich this study, based on the knowledge that portable water is required for construction work, a water quality test was conducted on raw water samples collected from all three sources in the block industry.

One of the most crucial NIS 87:2007 property criteria for testing and quality control of SCB is the water absorption test. After being weighed dry, each bought block sample was submerged completely in water for a whole day. The wet blocks were then weighed to determine the percentage of water absorption, as shown by Equation (1).

$$Wr = (WW - WD) / WD \times 100\% \qquad \text{Eq. (1)}$$

Where WD is the dry block weight
WW = wet block weight after 24 hours in water
Wr = water absorption

Each sample of blocks obtained from the block industry for testing was numbered and weighed in the dry state, during which the mass of each block was read and recorded. The weighing scale used had a weighing capacity of 50 kg and a graduation of 500 g. Then the dimensions of each block, i.e., length, width, and height, are taken from this volume, and the results are used to calculate the bulk density.

The ratio of the specimen's net surface area to the compressive load it can bear is known as its compressive strength. This test was conducted using a manual compression testing apparatus with a maximum load capability of 1500 kN. Testing was done on the 28th day of manufacture for SCB. To determine the crushing loads, ten (10) samples of both wet and dry blocks from various block businesses were crushed. Sixty (60) samples from various block factories were crushed in order to determine the blocks' compression on the net surface. Next, each block's compressive strength was determined. The ratio of a sample's net surface area to the compressive load (force) it can bear is known as its compressive strength in this context.

3. Result and Discussion

The experiment was carried out with laboratory analyses. There were two types of tests: the first concerned fine aggregates obtained from several block factories, and the second concerned SCB. The water absorption index, water quality test, compressive strength test, and sieve analysis are viable laboratory analyses.

3.1 Water Absorption Test Result

The Tables 1-3 show the water absorption of block samples collected from each block industry.

From equation 1,

Water absorption (w) = [(Wet block weight - Dry block weight) / Dry block weight] x 100

Table 1. Water Absorption Test (Block Industry A)

S/N	**Dry block weight M1 (kg)**	**Dry block weight M2 (kg)**	**W.A (%)**
1	23.26	25.57	9.93
2	23.34	25.82	10.63
3	23.36	26.64	14.04
4	23.15	26.08	12.66
Average W.A (A)= 11.82%			

Table 2. Water Absorption Test (Block Industry B)

S/N	**Dry block weight M1 (kg)**	**Dry block weight M2 (kg)**	**W.A (%)**
1	23.45	26.90	14.71
2	24.02	26.81	11.62
3	23.63	26.00	10.03
4	24.39	27.66	13.41
Average W.A (B)=12.44%			

Table 3. Water Absorption Test (Block Industry C)

S/N	**Dry block weight M1 (kg)**	**Dry block weight M2 (kg)**	**W.A (%)**
1	24.14	26.86	11.27
2	24.00	26.27	9.46
3	23.14	27.05	16.90
4	24.52	27.53	12.28
Average W.A (C)= 12.48%			

The water absorption rate obtained from the results presented in

Tables 1–3 shows that the sandcrete hollow block samples from two block industries had higher water absorption compared to the highest water absorption rate in NIS 87:2000 of 12%. The tables show that the average water absorption of the blocks is 11.82%, 12.44%, and 12.48% in block industries A, B, and C. The results show a significant range of values, where the lowest is 9.93% in block industry A" and the maximum is 16.90% in block industry "C," as shown in Table 3. This may be due to different mixing ratios, poor material selection (fine aggregate), and insufficient compaction of sandcrete hollow blocks, resulting in high water absorption. The consequence of high water absorption blocks is that a highly porous block can absorb more water in severe moisture conditions and therefore weaken and eventually collapse.

3.2 Water quality test

This was performed at the Water Laboratory, and the results are shown in Table 4.

Table 4. Physio-Chemical Parameters of Water Samples

S/N	**Parameters**	**Block Industry**			**NSDWQ**
		"A"	"B"	"C"	
1	Colour (PtCo)	80.0	274.0	46.0	15.0
2	Turbidity (NTU)	6.0	25.0	0	5.0
3	Suspended Solids (mg/L)	13	24	1	NS
4	PH	7.1	5.6	6.6	6.5-8.5
5	Total Hardness (mg/L)	160.0	70.0	226.0	150
6	Total Alkalinity (mg/L)	122.0	84.0	264.s0	NS
7	Chloride (mg/L)	70.0	14.0	108.0	250.0

8	Temperature (oC)	27.2	27.0	27.2	Ambient
9	Electrical Conductivity (μS/cm)	500	170	750	1000
10	Total Dissolved Solids (mg/L)	250	80	380	500
11	Nitrite (mg/L)	0.02	0.02	0	0.20
NSDWQ-Nigerian Standard for Drinking Water Quality NS-Not Stated					

Table 4 shows the result of the water quality analysis. Based on the results, the content of color, turbidity, and total hardness in the water sample of Block Industry "A" exceeds the permissible limits of the NSDWQ. The color and turbidity of the water sample from Block Industry "B" clearly exceed the limit established by the NSDWQ. A pH value of 5.6 is also outside the acceptable range. The pH value of the water sample from Block Industry C is within the acceptable range of 6.5 to 8.5 according to the NSDWQ, while other parameters are also good except the color, which is above the NSDWQ limit. In summary, it can be stated that none of the water samples from the block industry are portable and therefore suitable for use in construction work. However, this water is used in the construction of sand-concrete blocks.

3.3 *Particle Size distribution of soil Samples*

Particle size distribution analysis of the samples was carried out at the Soil Laboratory of the Department of Civil Engineering the Federal Polytechnic, Ilaro, Ogun State, Nigeria, and the results are shown in Figures 1 to 3.

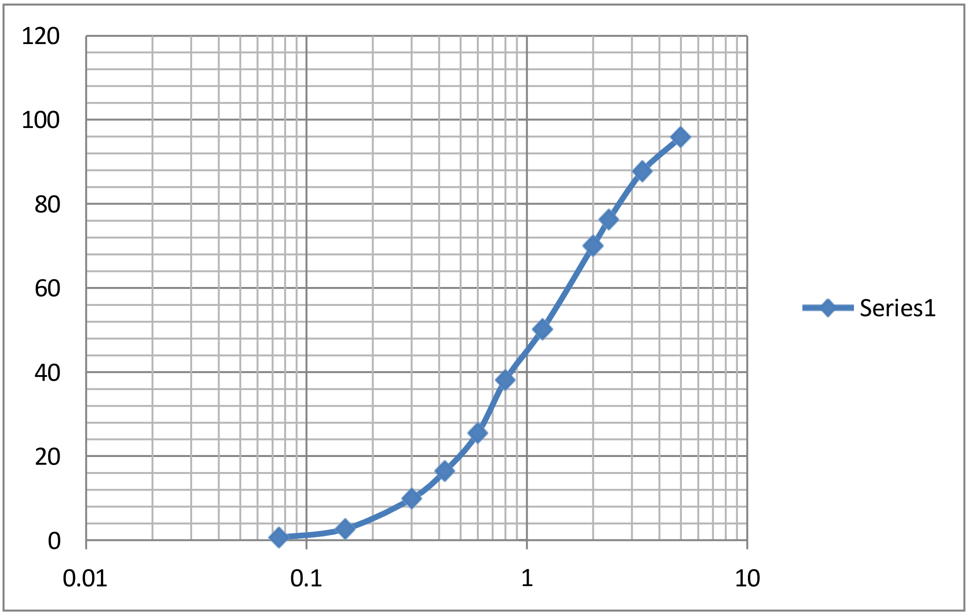

Fig. 1. Particle Size Analysis of Block Industry A

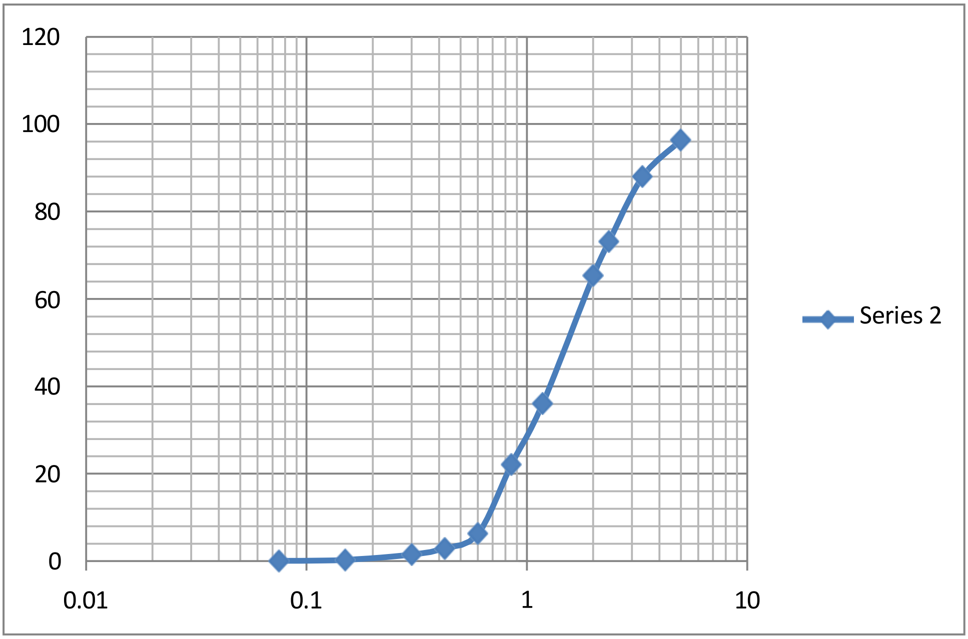

Fig. 2. Particle Size Analysis of Block Industry B

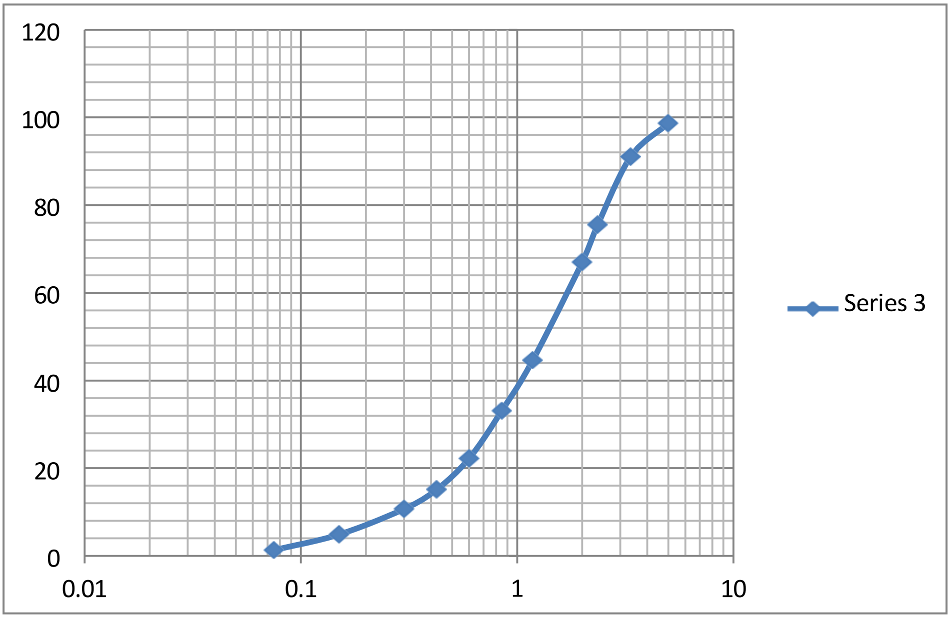

Fig. 3. Particle Size Analysis of Block Industry C

3.4 *Compressive Strength*

The compressive strength of a Sandcrete cavity measures the ratio of the compressive load (force) that the block specimen can withstand to its net surface exposed to the load. The instrument used in this analysis is known as a compressive load testing machine with a maximum load capacity of 1500 KN.

Compressive Strength (N/mm^2) = Crushing load/Net area of block where,

Block size = 450mmx225mmx225mm

Hollow section=2(150x150) =45, 000mm^2

Gross area of block = 450mmx225mm = 101, 250mm^2

Net area of block= Gross area of block – Hollow area

Net area of block=101, 250– 45, 000mm^2 = 56250mm^2

The tables below show the 28-day compressive strengths of various block samples from Ilaro, Ogun State.

Table 5. Compressive Strength Analysis (Block Industry A)

S/N	Block Weight	Crushed Load KN	Compressive strength N/mm^2
1	23.45	44.001	0.755
2	24.02	96.935	1.874
3	23.63	55.785	0.959
4	24.39	113.804	2.200
5	24.49	52.003	0.922
6	24.00	47.400	0.840
Average compressive strength= 1.258Nmm2			

Table 6. Compressive Strength Analysis (Block Industry B)

S/N	Block Weight	Crushed Load KN	Compressive strength N/mm^2
1	23.26	52	0.92
2	23.34	42	0.75
3	23.36	43	0.76
4	23.15	45	0.80
5	23.28	47	0.84
6	23.28	45	0.80
Average compressive strength= 0.81 N/mm^2			

Table 7. Compressive Strength Analysis (Block Industry C)

S/N	Block Weight	Crushed Load KN	Compressive strength N/mm^2
1	24.14	36	0.64
2	24.00	28	0.50
3	23.14	27	0.48
4	24.52	31	0.55
5	23.50	27	0.48
6	23.86	30	0.53
Average compressive strength= 0.53 N/mm2			

Tables 5-7 show the results of the average compressive strength of the sand and concrete cubes of each sample. The obtained results revealed that the average compressive strengths of the SCB samples were 1.258 N/mm^2, 0.81 N/mm^2, and 0.53 N/mm^2. Considering the methods and procedures of the tests carried out, and as can be seen from the curves, the following observations and conclusions are important to make regarding the nature and quality of SCB produced in Ilaro, Ogun State, Nigeria. The strength of SCB produced in Industry A is higher than in other industries (B and C). However, this is much lower than the Nigerian industry standard minimum value of 2.5 N/mm^2. The average total compressive strength value is 0.866 N/mm^2. The quality of sand and concrete blocks largely depends on the quality of the ingredients, i.e., cement, sand, and water/cement ratio. All sand particles used by Industries A, B, and C fall within Zone 1 of the BS 882 classification curve.

4. Conclusions

This study shows that some selected Sandcrete hollow block industries in Ilaro, Ogun State, Nigeria, did not meet the minimum requirements of NIS 87:2000 for compressive strength of 2.5 N/mm2 for machine compacted blocks and 2.0 N/mm2 for hand compacted blocks, while samples from some Sandcrete hollow block industries did not meet the minimum water absorption requirement of 12% in the Nigerian Industrial Standard. Particle size distribution analysis showed that all samples from each block industry significantly exceeded the 5.0 mm sieve size that is specified. However, the reference to the low-quality production of Sandcrete hollow blocks can be related to the fact that block manufacturers do not know about the existence of specifications for the production of Sandcrete hollow blocks, and the desire of the block industry to maximize profits is harmful the quality of the block produced. This research can be of great help in building regulatory agencies to ensure strict compliance and adherence to the quality production of standard Sandcrete pits in Nigeria State and Nigeria in general.

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CHAPTER 3

SIGNIFICANCE OF POLYHYDROXYALKANOATE (PHA) IN THE PRODUCTION OF BIOPLASTIC

Haruna Karamba

INTRODUCTION

Pollution can take place when gases, smoke and chemicals are bring into the environment in huge amount which courses detrimental effects on humans, animals, plants and on many other thing. Various type of pollution can be seen, but some are not visible with our naked eyes. Most of the environmental pollutions are happened because of recreational activities by mankind. Environmental Pollution takes place when pollutants contaminate the surroundings and brings about modifications that have a negative effect on our usual lifestyles. A pollutant is the basics or machinery of contamination the environment (Toukir, 2018). The actions of industries around universe are the major source of environmental pollution (Toukir, 2018). Due to indecent dumping of finish products to the environment this behavior results in contaminations of land and water bodies. Majority of these industries used petroleum as energy sources as well as extraction of many products. A lot of materials are derived from petroleum used for our daily life. Due to petroleum derived products particularly plastics, there is a lot of concern over the years in the increases of environmental effects course by these petroleum products. The impact of petroleum to the environment is not positive. Burning of gases from petroleum industries courses atmospheric pollution and a variety of sicknesses to the humans and animals as well. Climatic changes are also course by petroleum, due to the gas discharge during its production. This is the major effects course by petroleum and its derived products to the environment. But our concern here is the effects course by plastics which is one amongst the petroleum derived product that play a major role in polluting our environment. Petroleum-derived plastics (commercially synthetic plastics) they are extremely resistance to degradation. They happened to be important substance to human in day to day activities since they are used in many areas in life for the comport of living thing (Khanna, et al., 2009). Yearly almost one hundred and fifty million tones of synthetic rubbers are used around the glove. Synthetic plastic consumption is estimated to persist till year 2020 (Crank, et al., 2004). The procedure used for discarding of plastic materials is not easy and almost difficult. In the ground, decaying process is extremely time-consuming. Burning process produces negative effect to the environment and is also costly. Reuse is applicable except the process is longer as well as causes change to the contents of the synthetic rubber. Disposal of many plastic materials is very tricky and difficult to handle. Therefore, to reduce effects of synthetic plastics in the environment is by replacing the synthetic polymers with polymers of bacterial origin. Currently polymers from bacterial origin are getting consideration due to its ability to decay within the ground. Biopolymer accepted by scientist is polyhydroxyalkanoates (PHAs) due to its ability to decay in the environment. Polyhydroxyalkanoates have a related physicochemical property with conventional plastics (Braunegg, et al., 1998).

Increasing of synthetic rubber within the environment course a lot of negative effects to the entire world at large. To have pleasant substitute of synthetic plastics, scientists come with polymer from bacterial origin. Numerous organisms are able decompose these polymers (Mergaert, et al., 1992). These biopolymers have advantage against synthetic polymers they are not artificial and they can be decompose easily within the environment. The rate of biopolymer in microorganism was discovered in the year 1920s, by Lemoigne and he announced the presence PHB within bacteria (Lemoigne, 1926; Schubert et al., 1988). PHB is good example of PHA isolated firstly by French scientist Maurice L. in the year 1923 from bacteria. Plastics generated from PHB can be applied in every aspect. More than hundred PHAs were recognized from diverse group of microorganisms (DiGregorio, 2009). Until 1980s, scientists do not have chance to investigate better solution for synthetic plastics in order to reduce its effects. Early 80s, Anthony Sinskey together with his mates discovered enzyme ‘thiolase’ this enzyme play major important role in the production of biopolymers. Rights appliances of biopolymers was prepared in 1987 and lastly get acknowledged in1993 (DiGregorio, 2009).

Ability to degraded easily and decompose is the vital tools of biopolymers. The attractive material of PHAs which differentiate them with conventional polymers they have the ability to degrade easily in the environment. These biopolymers are firmed and anti wetness (Ojomu et al., 2004) and totally degraded to water and carbon dioxide in aerobic conditions and to methane and carbon dioxide in anaerobic conditions by microorganisms in ground and water environment (Khanna, et al., 2009). The degrading microorganisms generate extracellular PHA depolymerases, which convert the polyesters into water soluble oligomers and monomers that are used as a carbon source by the organisms (Reddy et al., 2003).

GENERAL PROPERTIES OF PHB

PHB a poly-3-hydroxybutyric acid homo-polymer it has a melting point of 179oC they are enormously (80%) crystal in character. Temperature above than the melting point leads to the decay of biopolymer. Various properties of PHB is resemble with polypropylene with three exceptional characteristics these are thermoplastic process capability, total water resistance and ability to total biodegradation (Hrabak, r1992). PHB common properties are water unsolvable, reasonably challenging to hydrolytic degradation, high-quality oxygen permeability, resistant to UV, liable to acids and bases, dissolve in chlorinated hydrocarbons as well as chloroform, non-toxic, biocompatible, high tensile potency (40MPa), sinks in water make possible anaerobic biodegradation and fewer sticky when melted make it potentially excellent material for clothing in expectations. PHA polymers with various subunit compositions and hence various physical and thermal properties can be tailor made using novel PHA syntheses for specific applications (Sharma, et al., 2017).

PHAs SOURCES

PHAs are members of biopolymers formed from diversity of Gram-positive and Gram-negative bacteria. Over 300 species, mostly bacteria are reported to generate these polymers (Olivera, et al., 2001). These bacteria can gather biopolymers in their inner cell (cytoplasm) as an intracellular carbon and energy reserve (Rocha, et al., 2008). Bacteria that are used for the manufacturing of PHAs can be devided into two groups based on the stress conditions required for PHA synthesis. The first division of bacteria requires the restriction of an important nutrient such as nitrogen, phosphorous, magnesium or sulphur with carbon source in abundance. The bacteria falling in this class are A. eutrophus, Protomonas extorquens and Protomonas oleovorans. The second division of this bacteria, are Alcaligenes latus, a mutant strain of Azotobacter vinelandii and recombinant E. coli do not need nutrient restriction for the synthesis of PHAs (Ojomu, et al., 2004).

POLYMERS DIVISION

Even though numerous elements can be molecules of artificial organic polymers, the major one are carbon (C), hydrogen (H), oxygen (O), and nitrogen (N). Best on the technique of polymers production is divided in to these divisions written below.

• Artificial polymers which acquired from the process of polymerization by objects of little

Molecular weight like polyethylene and nylon etc.

• Partially synthetic plastics are generated from processes natural polymers byproducts like nitrocellulose and etonita.

• Natural polymers acquired from animal or plant source, these are Cellulose, starch, protein, natural rubber, nucleic acid, chitin, lignin, etc. According to these divisions, the artificial polymers have make the gathering of plastic in our environment, pollution sources of atmospheric, visual, and also contamination of soil and marine environments (Webb et, al 2015). Hence, natural polymers, are in peak development, even though to posses them is limiting their appliance compare with synthetic plastic, nonetheless, the market for biopolymers is growing every year at alarming rate (O,brine and Thomson 2010), mostly increase limited ways to nonrenewable remnant resources play a role in the direction of discovering biopolymers with related properties of conventional plastics. (Ammala, et al., 2011).

USES OF BIOPLASTICS

Bioplastics are used for disposable items, such as packaging, cutlery, pots, bowls, and straws to mention but a few. In practice bioplastics in feature they can be put in place over synthetic plastics; but price and execution continue to be challenging. Bioplastics are favorite material then their counterpart. Example in Italy used of bioplastics is compulsory ever since 2011 with the introduction of a specific law. Not only structural products, electrical materials made with bioplastics are being developed to carry electric current. Bioplastics it is use in wide range of areas such as health, agriculture, production of disposable containers, and biodegradables bags. Apart from the well known applications of bioplastics such as production of polythen bags, receptacle, instrumentation and containers for soft drinks and dairy products, drugs can also be made from bioplastic. With the development of knowledge and technology, this biomaterial will mediate the manufacturing of products like cellular phones, cameras, medical equipments and automobile parts. The used of bioplastics in tissue engineering as a scaffolding material is currently gaining attention with king interest in the field of medicine (Misra, et al., 2006; Luklinska & Bonfield, 1997). They can be use to replace body parts as they are immunologically inert and degraded gradually within human tissue. They are also used by scientist to produce artificial bone implants, pacemaker, etc (Fedorov et al., 2005; Rossiiskaia, akademiia nauk, et al., 1995). Biopolymers are used to deliver drug agents slowly as well as steady discharge of drug in the body for longer time duration (Chen and Wu, 2005; Grage et al., 2009).

Studies associated with bioplastics in medical science are in first round phase and a lot of developments have to be done. Microcapsules of PHB origin have many applications in pharmacology such as managing and release of water soluble drugs, many types of proteins, peptides and nucleic acids. Managing release of Methylene green drug is encapsulated with PHB microcapsules is an example of biodegradable drugs (Bonartsev, *et al.*, 2007). Majority of polymers from bacterial origin is degradable; and coursing no injury to biological systems.

ADVANTAGES OF BIOPLASTICS:

They have the advantage to reduce synthetic materials from the environment.

- Used of bioplastics has an advantage of reducing carbon foot print.
- Bioplastics save energy during manufacturing.
- Bioplastics are not used utilization of products that are not from reused resources.
- Bioplastics does not add damage or injury to the health.

BIOPOLYMER

Biopolymers are essential substitute to petroleum derived polymers because of their ability to degrade easily, and have simple production procedure they can also be use in a variety of areas such as health and agriculture. And also produce via biorefineries as a division of biotechnology. Bioplastics of microbial origin are formed from diverse group of bacteria. Majority of bioplastics have the ability to decay in the environment with no serious health problem. All agreed with bioplastic from microbial source have the ability for storage of objects (Anbreen, *et al.,* 2016). In any problems, bacteria decayed biopolymers (Sukan, *et al*, 2015)**.** Biopolymers are degradable tools that come from reusable source to decrease difficulty in disposing of plastic which overpowering the universe by polluting our environment. Biopolymers or nutural plastics are form of plastics from biomass origins, like corn, starch or microbiota, they are pleasant than synthetic plastics which are derived from petroleum. Biodegradation is a procedure by which bacteria within environment modify substance into natural form like water and CO_2 etc.

EFFICIENT PHA PRODUCERS

Genera of bacteria like *Beneckea* and *Vibrio* i reported as the number one organism to produce PHB extracted in the sediments of marine (Lopez-Cortes, *et al*., 2008). Numerous types of bacteria, like, *Pseudomonas* spp. *megaterium*, *Ralstonia eutropha* score lots of attraction by scientist and these group of bacteria is extensively used because of their ability to produce PHB. Production of PHB by *Bacillus megaterium* is 84% under anaerobic conditions (Prasanna, *et al.*, 2011). However various group of bacteria such as *Actinobacillus*, *Azotobacter*, *Agrobacterium*, *Rhodobacter* and *Sphaerotilius* gained more attraction due to thire ability of changing organic waste such as wheat straw and rice husks to PHA. For industrial production of PHB, many haloarchaeal species such as *Haloterrigena*, *Halococcus*, *Haloquadratum*, *Haloferax*, *Haloarcula*, *Halobacterium*, *Halorubrum*, *Natronococcus Natronobacterium*, and *Natrialba* are also used for PHB production.

PHA FROM BACILLUS SPECIES

Bacillus species is able to produce organic and inorganic intracellular circular insertion bodies together with materials in the membrane and within cytoplasm of the cells. Clearly, occurrence of PHB granules in the microbial cytoplasm is provided as a chemotaxonomic mark in finding the variety of isolates. The large ranges of PHAs in Bacillus species make it to be essential producer of bioplastics (Swati, *et al*., 2017). Production of PHAs was examined by culturing *Bacillus* species in artificial environment ever since that time, biopolastics yield and the manufacturing differ significantly. Price is the main key issue upsetting huge amounts of PHAs manufacturing. Therefore, numerous cheap carbon sources like molasses from sugarcane and beet are mostly used manufacturing process of PHAs. However, it has been described that a variety of *Bacillus* species has the ability to make PHAs at diverse cheap price substrates. Comparatively the PHB yields in the activated sludge to artificial medium are 74% by *Bacillus megaterium* A9 and 76.32% *Bacillus mycoides* respectively (Swati, *et al.*, 2017). These authenticate the capacity of *Bacillus* species to make use of various complexes from starch. Very important to state, *Bacillus* species accepted because of the ability to make starch into easiest sugars like maltose & glucose by the used of enzyme like amylase to support. In the report of Eman (2014) *E. coli* and *B. subtilis* posses acceptable quantities of PHAs on media containing sugar molasses. Experiment proved that treated molasses with acid provide maximum cell weight (10.98 and 7.63 g/L, for *B. subtilis* and *E. coli*, correspondingly) when compared with crud molasses treated phosphate. PHA substance produce are 5.3 and 2.8 g/L, acquired by molasses treated with acid. Gazaerly (1983) report cited exclusion of mud from molasses decreases percentage of Zn and Cu almost 25%. Helal (1986) investigation on molasses simplified that H_2SO_4 when placed inside culture plate as nutrient source, shown that there was an improvement in the cell weight produces with a small reduction in nitrogen content. High amount of molasses enhanced maximum production of the species. Usually, when compare with *E.coli*, and *B. subtilis* illustrate an improvement in the cell dry weight, which ultimately leads to higher yield. Therefore, both organisms grow under molasses and make used of it as nutrients substrate (Eman, 2014).

PHA FROM PSEUDOMONAS SPECIES

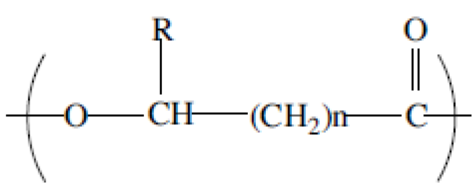
Some members of *Pseudomonas* produce PHA from the divers group of aromatic hydrocarbons. PHA gathering by aromatic hydrocarbons is revealed from three *Pseudomonas* species, these are *Pseudomonas putida, Pseudomonas oleovorans* and *P. citronellolis*. As a result there is no enough data on these species on gathering capacity of PHA inside them. *Pseudomonas. putida* CA-3, *Pseudomonas. putida* S12 and CA-1 when placed in medium containig styrene as nutreint source build up PHA from 8% to 14% weight of cells correspondingly (Tobin and O'Connor, 2005).

PHA FROM HALOMONAS SPECIES

Halophilic microbes are the most effective makers of polyhydroxybutyrate (PHB) because they are flexible even in very harsh conditions of the environment. Halomonas genus contains four genera, these are *Halomonas, Chromohalobacter, Alcanivorax* and the newly explained *Cobetia*, and two genera of nonhalophilic bacteria, *Zymobacter* and *Carnimonas* (Arahal, *et al*., 2002; Dobson & Franzmann, 1996; 1998; Yakimov *et al.*, 1998). Halomonas initially consider as one species i.e, *Halomonas elongata* (Vreelandn, *et al.*, 1980). But presently they have numerous members including newly discovered species *Deleya, Volcaniella* and *Halovibrio* before they are known as bacteria however have since been included in Halomonas. A number of them are identified due to quality they have passes in PHB production (Margesin and Schinner, 2001; Ventosa & Nieto, 1995). In this present time, rigorous investigation is currently carried out by researchers on PHAs production from bacteria by putting more effort is in progress to advance the methods (Khanna and Srivastava, 2009). Some haloarchae species have found to be efficient producers of PHB these are, *Haloferex, Haloarcula, Haloterrigrnr, Halorubum, Natrialba, Natronobacterium, Natronococus, Halobacterium* and *Haloquadratum*. Recently plactics of bacterial origin gained high concern from public and industries due to the broad deliberations seeking for improvement in the disposal of plastics materials (Doi 1990; Schlegel 1992; Steinbüchel, 1995). Halophilic microorganisms need a small amount of salt at least 0.2 M for their growth and cannot develop in the absence of salt. On the other hand, halotolerant bacteria grow up without salt and also in presence of moderately high salt concentrations (Ara, *et al.*, 2013). So base on this categories Halophiles comprise two groups with regard to salt need: one grow on media with 15 to 30% $NaCl_2$ known as extreme halophiles, and other one which grow in media with 3 to 15% $NaCl_2$ and is known as moderate halophiles. Extremely halophilic are members of Archaea, while moderate halophiles are from bacterial domain.

PHAs CLASSIFICATION AND STRUCTURE

Morphologically PHAs was classified into two family groups; short chain and medium chain length polyhydroxyalkanoates (Taguchi, *et al.*, 2004). Short-chain lengths PHAs contain 3–5 atoms carbon. Poly (3-hydroxybutyrate) P (3HB) and poly (4-hydroxybutyrate) P(4HB) are the example of this class of polymers. Medium-chain lengths PHAs contain 6–14 or above 14 atoms carbon. Homopolymers, poly (3-hydroxyhexanoate) P (3HHx) and poly (3hydroxyoctanoate), P (3HO) are the example of this class of polymers. (Kim, *et al.*, 2001).



PHB structure

PROPERTIES OF PHA

PHAs differ significantly in character both physically and chemically. Lacking an affinity to absorb water by PHAs, temperature, melting point, etc absolutely depend on the properties of monomer (Crank, *et al.,* 2004). Members of biopolymer display broad diversity of mechanical compositions from inflexible crystalline to flexible. The main restrictions during manufacturing of PHB is their essential unique development provision, costly materials like microorganisms and medium used in the production, methods of fermentati and elevated expenditure for their recovery play a major role in hindering productions of PHAs (Castilho, *et al*. 2009). Carbon source alone consume 50% expenses in the production of PHAs. Byproducts from Agro-industrial effluent can be use as carbon source like sugarcane molasses, oil and paper mill etc other than source from organic origin (Halami 2008). Reprocesses from above mention effluents in manufacturing of polyhydroxyalkanoate is difficult process (Thomsen 2005).

PROPERTIES OF SHORT-CHAIN-LENGTH AND MEDIUM-CHAIN-LENGTH

PHA Short-chain-length bioplastics are inflexible and posses large quantity of crystalline between 60–80% where as medium-chain-length bioplastics is elastic with little crystalline of 25% (Reddy, *et al.*, 2003).

IMPORTANCE OF PHB TO MICROBES

PHB is extremely significant for microbes. Under less nutrient conditions, intracellular gathering of PHB accumulates up to a point of 90% weight of dry cell (Madison & Huisman 1999). Once the availability of nutrient sources like nitrogen and phosphorus is less and carbon is in excess, PHB acts as energy storeroom. PHB act as a redox controller inside the cell and in some bacteria such as *Ralstonia eutropha* and *Rhodospirillum rubrum,* it is involved in pyridine nucleotide dependent reduction of acetoacetyl-CoA. (Senior, and Dawes, 1973; Steinbüchel, 1991). Encystment of *Azotobacter* cells is moreover related with PHB accumulation. For the period of starvation, presence of PHB protects the cellular components like RNA and proteins (Vinet & Zhedanov, 2010) and it plays a significant role in sporulation. Many bacterial that produce PHB have been extracted from freshwater and soil point out PHB gathering is an ordinary process of several bacteria for dealing hash conditions (Galia, 2010; Nielsen *et al.,* 2017).

PHA PRODUCERS BY PHOTOSYNTHETIC BACTERIAS

Cyanobacteria are an example of photosynthetic organisms which have very small generation time, and they are used to generate bioplastics from atmospheric condition. Research reveals many number of cyanobacteria normal have the ability for accumulating biopolymers. Several Cyanobacteria like synechococcus species, spirulina platensis and nostoc muscorum produce PHAs when phosphate is limited (Panda, *et al.*, 2005). Phosphorus deficient conditions and supplementation of 0.4% of acetate resulted in gathering of biopolymer with 29% cell dry weight (Panda, *et al.*, 2006).

Synechocystis sp. PCC 6803 when placed under nitrogen, phosphorus, and also with limitation of exchange gas will improved biopolymer productions (Panda, *et al.*, 2007). Sulfur poor conditions improved biopolymer substance (Melnicki, *et al.*, 2009). Nostoc muscorum can generate biopolymer of sufficient amount when using with mixotrophy, chemoheterotrophy and also under nitrogen limitation conditions per better in comparising with photoautotrophic conditions (Sharma and mallick 2005). Addition of external sources of carbon, pH, and temperature establish to monitor accumulation of biopolymer in Nostoc muscorum (Sharma and mallick 2005). Cyanobacteria have the ability to generate biopolymer with acquired energy from sunlight produce out come and also reducing the price of CO_2 (Wu, *et al*., 2002).

ANAEROBIC AND AEROBIC SYSTEMa

Managing of plastics disposal with the use of aeration and unaeration methods is known as improvement removal of biological phosphate is the most efficient methods with high opinion in current PHA invention by using enhance stimulated mud. Manufacturing of biopolymers with phosphorus accumulating organisms has been discovered initially by two researchers Wallen and Rohwedder (1974). PAOs build up biopolymers from the breakdown of polyphosphate in the absent of oxygen (Santos, *et al*, 1999). Moreover, using of phosphate as manure in the land is very important for cultivated plant (Corre, *et al.*, 2009). Microlunatus phosphovorus from activated sludge was studied for its ability to store PHB under anaerobic or aerobic provision and good nutrient sources for development. Phosphorus accumulating organisms are the most prospective applicant for biopolymer production in the present small fatty acid (Akar, *et al*., 2006).

CONCLUSION

Commercially synthetic plastic is the major source of pollutants in the present days all over the universe. A solution must be put in place in order to change this synthetic plastic problem, used by mankind for taking materials such as food stocks etc. Bioplastics are rising speedily since they have clear importance in various appliances. Their carbon footprint can be much minor than oil-based counterparts. Bio-plastics can present brilliant biodegradability assisting the world to reduce the escalating harms of litter in the environment and mostly in the world's rivers, sand and seas.

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CHAPTER 4

SPECTROSCOPIC STUDY OF CERAMIC MEMBRANES FOR WATER PURIFICATION

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INTRODUCTION

Access to clean and safe drinking water is a global challenge, prompting the development of advanced water treatment technologies. Ceramic membranes offer distinct advantages over polymeric membranes, such as superior chemical resistance, thermal stability, and mechanical strength. Their precise pore size distribution enables efficient removal of contaminants while maintaining high water permeability. This paper explores the spectroscopic techniques employed to characterize ceramic membranes, understand their surface properties, investigate fouling mechanisms, and optimize their performance for water purification.

Literature Review

Historical Development of Ceramic Membranes

The development of ceramic membranes dates back to the late 20th century, driven by advancements in materials science and membrane technology. Early research focused on improving membrane fabrication techniques and enhancing pore structure control to achieve optimal filtration efficiency (Field et al., 1993). The evolution of ceramic materials and manufacturing processes has enabled the production of membranes with tailored properties for diverse water treatment applications.

Properties of Ceramic Membranes

Ceramic membranes exhibit several advantageous properties that make them suitable for water purification:

- **Chemical and Thermal Stability**: Ceramic materials are resistant to harsh chemicals and high temperatures, ensuring long-term performance and durability.
- **Mechanical Strength**: The inherent strength of ceramics allows for high-pressure operation and reduces the risk of membrane damage during handling and operation (Topcu, 2024).
- **Precise Pore Size Distribution**: Controlled pore sizes enable selective removal of contaminants while maintaining high water flux rates.
- **Surface Hydrophilicity/Hydrophobicity**: Surface modifications influence membrane fouling behavior and water permeability, enhancing operational efficiency (Zhang et al., 2015).

Spectroscopic Techniques for Ceramic Membrane Analysis

Fourier-Transform Infrared Spectroscopy (FTIR)

FTIR spectroscopy is widely used to analyze the chemical composition and functional groups present on the surface of ceramic membranes. It provides insights into surface modifications, interactions with water molecules, and changes in membrane chemistry under different operating conditions (Jin et al., 2018).

X-ray Photoelectron Spectroscopy (XPS)

XPS enables elemental analysis and determination of chemical states on the membrane surface. It identifies surface contaminants, oxidation states, and chemical modifications that affect membrane performance and fouling behavior (Yu et al., 2016).

Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray Spectroscopy (EDS)

SEM-EDS analysis offers detailed morphological characterization of ceramic membranes, including pore structure, surface roughness, and distribution of elements (Demirkan and Topcu, 2022; Topcu, 2022; Topcu, 2020). It helps correlate membrane structure with performance parameters such as permeability and fouling resistance (Zhang et al., 2020).

Applications of Ceramic Membranes in Water Purification

Ceramic membranes are employed in various water treatment processes, including microfiltration, ultrafiltration, nanofiltration, and reverse osmosis. Their application extends to treating industrial wastewater, desalination, drinking water purification, and environmental remediation. Case studies highlight successful implementations and performance optimizations using spectroscopic techniques to monitor membrane integrity, fouling dynamics, and water quality standards compliance (Ma et al., 2019).

Spectroscopic Study of Ceramic Membranes

Fouling Mechanisms and Mitigation Strategies

Spectroscopic studies elucidate fouling mechanisms on ceramic membranes, including organic fouling, inorganic scaling, and biofilm formation. Understanding surface interactions and fouling kinetics informs the development of effective fouling mitigation strategies, such as surface modification, backwashing protocols, and chemical cleaning regimes (Wang et al., 2017; Baytak et al., 2022;).

Performance Optimization and Future Directions

Ongoing research focuses on enhancing ceramic membrane performance through advanced spectroscopic analysis and materials engineering. Future directions include the integration of nanotechnology, membrane surface modification, and hybrid membrane systems to achieve higher water recovery rates, energy efficiency, and sustainability in water treatment processes.

CONCLUSION

Spectroscopic techniques play a crucial role in advancing the understanding and optimization of ceramic membranes for water purification. By analyzing membrane structure, surface chemistry, and fouling behavior, spectroscopy contributes to the development of robust, efficient, and sustainable water treatment technologies. Continued research and innovation in spectroscopic analysis and membrane materials will drive the evolution of ceramic membranes towards meeting global water quality challenges.

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