EVALUATION OF THE EFFECTIVENESS OF AUTOMOBILE WASTEWATER AS A CONSTITUENT OF CONCRETE PRODUCTION

BY

EZEDI, Onyekachukwu Mercy

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CERTIFICATION

This is to certify that this work was carried out by EZEDI ONYEKACHUKWU MERCY with Matriculation Number, ENG1704018, of the Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin-City, Edo State, Nigeria.

Name: Engr. P. N Ogbeifun **Date**

Project Supervisor

Name: Dr. (Mrs.) N.I Ihimekpen **Date**

Head of Department

DEDICATION

I dedicate this project to God Almighty for the wonderful works he has done in my life and for seeing me through all the hurdles and also to my beloved parents, late Mr. Andrew Okonji Ezedi and Mrs. Helen Uche Ezedi for being my source of inspiration and for their unwavering support to consider my education as priority.

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ABSTRACT

In our pursuit of sustainable solutions to address environmental challenges, the treatment and reuse of wastewater have gained significant attention. The automobile industry, renowned for its substantial water consumption and discharge, has emerged as a focal point for exploring innovative approaches to wastewater management. This study investigates the potential applications, benefits, and challenges associated with utilizing automobile wastewater in construction activities. The scope of work involved collecting samples from car wash facilities, analyzing chemical and mineral properties, preparing concrete mixes, and conducting tests using both potable water and automobile wastewater.

Laboratory tests on the automobile wastewater samples demonstrated that key parameters such as Total Dissolved Solids (TDS), chloride (Cl^-), bicarbonate (HCO_3), and sulfate (SO_4) were within standard limits for concrete production. Notably, the setting time tests on cement molds revealed a significant 27.73% reduction in initial setting time and a 14.81% increase in final setting time using first wash compared to potable water. The use of second wash resulted in a more substantial 45.38% decrease in initial setting time and a modest 3.70% increase in final setting time. Slump tests correlated detergent concentration with higher values for the first wash. However, the compression tests on concrete indicated a decrease in strength, with a 35.96% reduction at 28 days against first wash and a more significant 54.75% reduction against second wash.

In conclusion it is evident that for automobile waste water to be used for concrete production, it must undergo process of treatment. As recommendation, it is advised to implement effective treatment processes for automobile wastewater before incorporating it into concrete production, ensuring that the construction materials meet required standards and contribute to sustainable environmental practices in the automobile industry.

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ACRONYMS

AOP – Advanced Oxidation Process

APHA – American Public Health Association

ASTM – American Standard for Testing and Materials

BOD – Biological Oxygen Demand

COD – Chemical Oxygen Demand

DOE – Design Of Experiments

NF – Nano filtration

PAH – Polycyclic Aromatic Hydrocarbons

RO – Reverse Osmosis

TDS – Total Dissolved Solids

TS – Total Solids

TSS – Total Suspended Solids

UF – Ultrafiltration

UV – Ultraviolet

VOC – Volatile Organic Compound

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

In recent years, people's environmental awareness has increased. The high density of the urban population has caused a considerable increase in the demand for car washing services, which has created large quantities of car wash wastewater. The main pollutants in car wash wastewater are detergents, dirt, oil, and grease. Untreated wastewater released into rainwater sewer systems or other water bodies may pollute the water and generate excessive bubble foams, which negatively affects urban appearance (Kuan *et al.*, 2022).

In our pursuit of sustainable solutions to address environmental challenges, the treatment and reuse of wastewater have gained significant attention. The automobile industry, renowned for its substantial water consumption and discharge, has emerged as a focal point for exploring innovative approaches to wastewater management. Automobile wastewater, traditionally considered complex and challenging due to its composition of contaminants such as heavy metals, oils, solvents, and suspended solids, is now being explored for its potential applications in construction (Kassim *et al.*, 2018).

Additionally, automobile wastewater can play a role in concrete production, where it can be utilized as a substitute for freshwater, thereby reducing the industry's water footprint (Dong *et al.*, 2022). Treated automobile wastewater can contribute to soil stabilization and dust control measures on construction sites, providing an alternative to traditional water-based methods (Zhu *et al.*, 2020).

While these innovative practices hold promise, certain challenges need to be addressed. The effective treatment of automobile wastewater to meet construction standards and regulations is crucial (Jiang *et al.*, 2021) and the long-term environmental and health impacts, as well as the economic viability and scalability of these practices, require careful consideration (Zhu *et al.*, 2020).

1.2 Statement of Problem

The automobile industry is known for its substantial water consumption and the generation of wastewater that poses environmental challenges due to its complex composition, including contaminants such as heavy metals, oils, solvents, and suspended solids. The disposal of untreated automobile wastewater can have detrimental effects on water sources and ecosystems. Furthermore, the construction industry, characterized by its high-water demand, faces the challenge of sourcing sustainable water alternatives to meet its needs while minimizing the strain on freshwater resources.

To address these challenges, there is a need to explore innovative approaches to wastewater management that can transform automobile wastewater into a valuable resource for the construction sector. However, several significant issues must be considered and addressed for the successful utilization of automobile wastewater in construction applications.

Firstly, the treatment of automobile wastewater to meet construction standards and regulations is crucial. The removal of contaminants and the achievement of suitable water quality require advanced treatment processes and robust monitoring systems to ensure the safety and compliance of repurposed wastewater (Cassardo and Jones, 2011).

Secondly, the compatibility of treated automobile wastewater with construction materials and processes must be thoroughly evaluated. It is essential to assess the potential impacts on the performance, durability, and integrity of construction materials when incorporating wastewater, particularly in applications such as concrete production or soil stabilization.

1.3 Aim and Objectives of the Study

The aim of the study is to investigate the potential applications, benefits, and challenges associated with utilizing automobile wastewater in construction activities.

Specific objectives include:

i. Assess the quality, composition and characteristics of automobile wastewater generated by the automobile industry.
ii. Investigate the feasibility and performance of utilizing automobile wastewater as a construction material.
iii. Examine the effects of incorporating automobile wastewater as a substitute for freshwater in concrete production, analyzing its impact on concrete workability and strength.

1.4 Scope of Work

The following are the scope of work in this study:

i. Collection of samples of automobile wastewater from car wash facilities or other relevant sources.
ii. Conducting laboratory tests to analyze the physical, chemical and biological properties of the wastewater.
iii. Carrying out Slump tests on prepared concrete.

iv. Preparation of concrete mix and concrete casting.

v. Determination of the compressive strength of concrete casted using automobile wastewater.

1.5 Justification of Study

The automobile industry generates significant amounts of wastewater that can have adverse effects on water sources and ecosystems if not properly managed. By exploring the utilization of automobile wastewater in construction, the study aims to contribute to reducing the environmental impact of the automobile industry and promote sustainable wastewater management practices.

The construction industry is a major consumer of freshwater resources. By repurposing treated automobile wastewater as a substitute for freshwater in construction activities, the study aims to conserve water resources and alleviate the strain on freshwater supplies.

This study aligns with the principles of the circular economy by transforming a waste stream, automobile wastewater, into a valuable resource for the construction industry. This approach promotes resource efficiency, waste reduction, and the development of sustainable practices in both industries.

Incorporating treated automobile wastewater in construction materials and processes has the potential to enhance the sustainability of construction practices. This study aims to assess the feasibility and benefits of utilizing automobile wastewater, contributing to the advancement of sustainable construction practices.

The study seeks to evaluate the economic viability of implementing automobile wastewater reuse in construction. If proven economically feasible, the utilization of treated wastewater can offer cost savings for the construction industry, reducing the reliance on freshwater sources and lowering operational expenses.

By investigating the treatment processes and quality control measures for automobile wastewater, the study aims to ensure compliance with construction standards and regulations. It provides valuable insights for policymakers, regulators, and industry stakeholders in developing guidelines and frameworks for the safe and sustainable utilization of automobile wastewater.

While there is a growing interest in wastewater management and reuse, the specific utilization of automobile wastewater in construction is an emerging field. This study aims to bridge the knowledge gap by providing comprehensive insights into the potential applications, benefits, and challenges of utilizing automobile wastewater in construction.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Essence of Water

The second most important element to our survival after air is water. Water covers the majority of the surface of the earth. That contains 96.5% of the salt water found in seas and oceans. Freshwater makes up 2.5% of the mixture. However, about 2% of this freshwater exists as ice, so we can use the 1% of freshwater that is available to us. Both the surface water and the groundwater of this freshwater are accessible (Cassardo and Jones, 2011).

In addition to this, Agriculture, Industry, and families all rely on water to provide them with various products (such as drinking water and irrigation water) and services (such as hydroelectricity generation, recreation, and amenity) (Sultana, 2018).

2.2 Water Needs

Due to several causes, including an expanding population, rising agricultural needs, industrial water consumption, and the need for water for the generation of power, etc., there is an enormous growth in the need for water. Because of the ongoing growth of the economy and population, this dilemma is more pressing than ever. Today's challenge is to develop prudent water usage practices. One of the most efficient methods of water saving in this competition may be considered to be water recycling (Neelofar *et al.*, 2023).

2.3 Recycling and Reusing Water

Despite the fact that there is a growing global crisis involving the lack of access to high-quality water, water-related problems and issues are frequently seen as being localized. Reusing and recycling water will be crucial in the future for protecting public health and achieving sustainability (Rose, 2007) . Utilizing treated water for a variety of industrial, home, and agricultural uses while treating waste water to remove pollutants is the definition of recycling and reusing water. "Water reclamation" is another name for it.

The following are some advantages of recycling and reusing water:

1) Water recycling can reduce the discharge of effluents that may harm and pollute ecosystems

2) Recycled water can satisfy the majority of water demands; water recycling offers resource and financial savings

3) Waste water reuse contributes to national development.

A distinctive and practical opportunity to supplement conventional water supplies is provided by water reclamation and reuse. Reusing water can help close the loop between water supply and wastewater disposal because it is a multi-disciplined and crucial component of the development and management of water resources. The functions of the water supply and the reclaimed water supply must be integrated for effective water reuse. The efficient development of this dependable water resource depends on the careful consideration and synthesis of factors from the planning of infrastructure and facilities, the location of wastewater treatment facilities, the dependability of the treatment processes, economic and financial analyses, public acceptance, and water utility management. (Mo and Zhang, 2013)

2.4 Trends in Car Wash Technology

There are several different kinds of professional car washing, including self-serve, in-bay automatic, conveyor, touch-free (touch less), and hybrid. Self-serve car washes let customers wash their own vehicles. Water is spread using a wand, and low-pressure brushes are employed. Gas stations are where you'll find most In-Bay Automatic Car Washes. The coin-operated car wash machine sweeps back and forth over the vehicle as the driver parks it. The most cutting-edge vehicle wash system is Touch Free Car Washing Technology. It uses a touch-free cleaning method in which only water and mild soap solutions come into contact with the car. They operate without making touch, therefore wash equipment damages are reduced. Additionally, the ability to gauge each vehicle's length and width saves time, water, and chemical solutions. The foundation for completely touch-free washing is high water pressure with low volume flow. In the wash bay, the driver parks the car. One spray arm goes back and forth to clean the car while it is still in motion. Effective and consistent chemical application is necessary for good cleaning results (Janik and Kupiec, 2007).

2.5 Composition and Characteristics of Automobile Wastewater

There is a high concentration of various pollutants in the wastewater from car washes, including surfactants, phosphorus, nitrogen, solids, organic matter, and oil content. (Kashi *et al.*, 2021). This section focuses on understanding the composition and characteristics of automobile wastewater.

2.6 Pollutants in Automobile Wastewater

Automobile wastewater typically contains a diverse range of pollutants, which can be categorized into several key groups:

i. **Oils and Hydrocarbons**: Vehicle fluids such as engine oil, transmission fluid, and hydraulic fluids can contaminate wastewater through leaks, spills, and improper disposal practices. These hydrocarbons contribute to the organic pollutant load in automobile wastewater (Abuhasel *et al.*, 2021)

ii. **Heavy Metals**: Automotive activities result in the release of heavy metals such as lead, copper, zinc, and cadmium. These metals are derived from vehicle components, brake wear, exhaust emissions, and surface runoff from roads and parking lots. They pose environmental risks due to their toxicity and potential for bioaccumulation. (Agoro *et al.*, 2020)

iii. **Suspended Solids**: The majority of the time, the wastewater from car washes includes suspended solids that come from the dirt on the vehicles, the oil on the vehicles' exteriors, the oil and grease produced by the car wax, and the anionic surfactants produced by the use of detergents (Hu *et al.*, 2022).

iv. **Surfactants:** Car washing processes and cleaning agents used in automotive facilities introduce surfactants into automobile wastewater. Surfactants are pollutants whose main job is to wet and disperse impurities in the liquid that don't mix with it by reducing surface tension at the phase interface. The primary benefits of surfactants include their washing, wetting, emulsifying, dispersing, stabilizing, and foaming properties. However, surfactant can contribute to foaming and water pollution if not properly managed. (Lobotková *et al.*, 2023)

v. **Trace Elements**: Exhaust emissions and wear of vehicle parts can release trace elements, including heavy metals, metalloids (such as arsenic), and other contaminants such as polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). These elements may be present in automobile wastewater and can have detrimental effects on water quality and ecosystems (Al-Zarah, 2014).

2.7 Potential Impacts of Pollutants on Construction Materials

The presence of certain contaminants in automobile wastewater can have implications for the performance and durability of construction materials. For example, oils and hydrocarbons may affect the adhesion and bonding properties of concrete and asphalt, potentially compromising their structural integrity (Wilson *et al.*, 2001).

2.8 Treatment Technologies for Automobile Wastewater

The treatment of automobile wastewater is essential to remove pollutants and ensure its safe reuse or discharge. Various treatment technologies are available to effectively treat and manage automobile wastewater. This section provides an overview of commonly used treatment technologies for automobile wastewater (Kuan *et al.*, 2022).

i. Sedimentation

Sedimentation is a primary treatment process that allows the settling of suspended solids and heavy particles present in automobile wastewater. The wastewater is allowed to stand in a tank or basin, facilitating the gravitational separation of solids from the liquid phase.

Sedimentation helps remove particulate matter and facilitates subsequent treatment processes by reducing the pollutant load (Rubi *et al.*, 2009).

ii. Filtration

Filtration is a widely used treatment method for removing suspended solids and fine particles from automobile wastewater. Different types of filters, such as sand filters, activated carbon filters, and multimedia filters, can be employed to effectively trap and remove solid particles. Filtration improves water clarity and reduces turbidity, enhancing the overall quality of treated wastewater (Hu *et al.*, 2022).

iii. Coagulation and Flocculation

Coagulation and flocculation are chemical treatment processes commonly used to remove colloidal particles, dissolved metals, and organic matter from automobile wastewater. Coagulants, such as aluminum or iron salts, are added to the wastewater, causing the formation of larger particles called flocs. Flocculants, such as polymers, are then introduced to facilitate the aggregation and settling of the flocs, resulting in improved removal of contaminants (Bakar and Halim, 2013).

iv. Biological Treatment

Biological treatment processes utilize microorganisms to degrade organic matter and nutrients present in automobile wastewater. Common biological treatment methods include activated sludge process, trickling filters, and sequencing batch reactors. These processes provide an environment for microbial growth and activity, leading to the breakdown of organic pollutants and the reduction of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (Mallick and Chakraborty, 2019).

v. Advanced Oxidation Processes (AOPs)

Advanced oxidation processes involve the use of oxidizing agents or energy sources to degrade and remove contaminants in automobile wastewater. Examples of AOPs include ozonation, ultraviolet (UV) radiation, and advanced oxidation with hydrogen peroxide or ozone. These processes generate highly reactive species that oxidize and break down organic compounds, facilitating their removal from the wastewater (Garrido-Cardenas *et al.*, 2020).

vi. Membrane Processes

Membrane processes, such as reverse osmosis (RO), Nano filtration (NF), and ultrafiltration (UF), are effective in removing dissolved solids, salts, and contaminants from automobile wastewater. These processes rely on semipermeable membranes that selectively allow the passage of water molecules while rejecting pollutants. Membrane filtration can produce high-quality treated water suitable for various applications, including construction purposes (Uçar, 2018).

vii. Adsorption

Adsorption is a process that involves the attachment of contaminants to a solid surface, known as an adsorbent. Adsorbents, such as activated carbon or specific resins, can effectively remove organic compounds, heavy metals, and some dissolved pollutants from automobile wastewater. Adsorption is commonly used as a polishing step in conjunction with other treatment processes to further enhance the quality of treated wastewater (Rashid *et al.*, 2021).

viii. Disinfection

Disinfection is the final treatment step that aims to eliminate or inactivate harmful microorganisms in automobile wastewater. Common disinfection methods include chlorination, ultraviolet (UV) disinfection, and ozonation. Disinfection ensures the microbiological safety of treated wastewater, particularly when it is intended for reuse in construction or another application (González *et al.*, 2023).

2.9 Construction Applications of Automobile Wastewater

The following are the applications of Automobile Wastewater in construction activities;

i. Dust Suppression

Construction sites often generate excessive dust, which can be problematic for worker health, nearby residents, and the environment. Treated automobile wastewater can be used for dust suppression by spraying it onto construction areas. The water content helps bind the dust particles, reducing their dispersal and minimizing air pollution (Tasker *et al.*, 2018).

ii. Concrete Mixing and Curing

Automobile wastewater treated to meet the required quality standards can be used in concrete mixing and curing processes. The water can replace freshwater as a mixing component, reducing the demand for freshwater resources. It can enhance the workability of the concrete mixture and contribute to the hydration process, leading to the desired strength and durability of the concrete (Arooj *et al.*, 2021).

iii. Soil Stabilization

Treated automobile wastewater can be utilized for soil stabilization purposes in construction projects. By applying the wastewater to unstable or loose soil, it can enhance soil compaction and cohesion, resulting in improved stability and load-bearing capacity. This application is particularly useful in road construction, where treated wastewater can be used to stabilize subgrade soils (Abed *et al.*, 2018).

iv. Landscaping and Greenery

Automobile wastewater, after suitable treatment, can be used for landscaping and irrigation purposes in construction projects. It can be employed for watering plants, lawns, and green spaces, providing an eco-friendly water source and reducing the reliance on freshwater supplies. Properly treated wastewater can provide essential nutrients to support plant growth and contribute to sustainable landscaping practices (Ramaiah *et al.*, 2022).

v. Construction Site Cleaning

During construction activities, the cleaning and washing of equipment, machinery, and construction vehicles are necessary. Treated automobile wastewater can be utilized for these cleaning purposes, reducing the need for freshwater and minimizing environmental impact. It ensures effective cleaning while optimizing water resources (Dadebo *et al.*, 2022).

vi. Road Dust Control

In areas where unpaved roads or construction site access roads generate significant dust, treated automobile wastewater can be applied to control dust emissions. By spraying the treated wastewater onto the road surfaces, dust particles are effectively bound, reducing airborne dust and improving air quality in the surrounding areas (Xing *et al.*, 2018).

2.10 Environmental and Economic Considerations of Utilizing Automobile Wastewater in Construction

The utilization of automobile wastewater in construction applications brings both environmental and economic benefits. However, it is crucial to consider the potential environmental impacts and evaluate the economic feasibility of such practices. This section explores the environmental and economic considerations associated with using treated automobile wastewater in construction.

2.10.1 Environmental Considerations

i. Water Conservation

By utilizing treated automobile wastewater in construction, freshwater resources can be conserved. This helps alleviate the strain on local water sources, especially in regions experiencing water scarcity or drought conditions. By reducing the demand for freshwater, the environmental impact of water extraction is minimized, preserving natural ecosystems and maintaining ecological balance (Dogan and Seker, 2016).

ii. Reduced Discharge into Water Bodies

Proper treatment of automobile wastewater before its use in construction ensures that pollutants and contaminants are effectively removed or reduced. This significantly reduces the discharge of harmful substances into water bodies, preventing water pollution and protecting aquatic ecosystems. Using treated wastewater instead of discharging it directly into water bodies helps maintain water quality and preserve the biodiversity of surrounding environments (Obaideen *et al.*, 2022).

iii. Reduction of Climate change Effects

The growth of the renewable sector will aid in lowering the amount of CO2 emitted by massive power plants and the electrical manufacturing sector.

Industries are now emphasizing resource recycling instead of discharging wastewater into the soil and rivers. The program lessens the effects of acid rain and climate change.

Additionally, by doing this, we can lessen the rapid, unpredictably changing climate and safeguard the ecosystem from pollution (Mamais *et al.*, 2015).

iv. Soil Quality and Erosion Control

Treated automobile wastewater used for soil stabilization in construction projects can enhance soil quality and control erosion. By improving soil compaction and cohesion, the risk of erosion is reduced, preventing soil loss and maintaining soil fertility. This contributes to the preservation of natural ecosystems and protects nearby water bodies from sedimentation and pollution (Nnaemeka *et al.*, 2014).

2.10.2 Economic Considerations

Job Creation and Revenue Generation

By providing employment opportunities, expanding wastewater treatment facilities would likely generate a sizable number of jobs that would engage a range of professionals. The economy of the nation will benefit from this in a variety of ways because those who invest in the treatment plants will make it possible for numerous industries to operate and produce the equipment that the treatment plants require. The country's economy will grow as a result of the increased foreign revenue, which will also help to partially solve the problem of unemployment, which is a major issue in developing nations. The GDP will rise as a result (Timmis *et al.*, 2017).

2.11 Challenges and Limitations of Utilizing Automobile Wastewater in Construction

The following are some of the challenges and limitations listed below

i. High levels of pollution: The wastewater from automobiles contains high levels of suspended solids, hydrocarbons, flammable liquids, fats, oil, and grease. (Singh *et al.*, 2022)Because of this, using it for construction purposes is difficult.

ii. Limited Treatment Options: There aren't many options for treating automotive wastewater, and some of the treatments may not be able to completely get rid of all the contaminants. This may reduce the wastewater's suitability for construction-related uses (Kesari *et al.*, 2021).

iii. Regulatory requirements: The use of treated wastewater in developed nations follows strict rules and regulations. It is important to note that the direct use of untreated wastewater without any sound regulatory policies is evident in developing nations, which leads to serious environmental and public health concerns. However these requirements can be difficult and time-consuming to follow (Dickin *et al.*, 2016).

2.12 Public Perception and Acceptance

Perception in developing nations: Reusing wastewater is generally seen favorably in developed nations compared to developing nations. The safety and quality of the wastewater continue to be issues, though. A study done in Canaan land, a developing urban community in Nigeria, revealed that the community was aware of the economic and environmental benefits of wastewater reuse but would prefer reuse programs that involved less human contact, such as flushing toilets, producing electricity, building, and car washes. For potable uses, the least desired alternative was selected (Akpan *et al.*, 2020).

2.13 Regulatory Framework and Guidelines for Utilizing Automobile Wastewater in Construction

ASTM C1602 standard: ASTM C1602/C1602M-18 (2018) does not impose any restrictions on the amount of chloride in the water used to mix unreinforced concrete. This standard permits the use of wastewater as concrete mixing water. According to ASTM C1602, water used to mix concrete must have a TDS limit of less than 50,000 ppm. Other standards set a maximum TDS limit of about 2000 ppm. Similar requirements for the use of treated wastewater in concrete mixing were found in both the ASTM and Turkish standards, according to a comparative study of their respective specifications for mixing water (Aldossary *et al.*, 2020).

2.14 Concrete and its General Properties

Concrete, specifically Portland cement concrete, has the qualities of strength, durability, versatility, and economy, and can be placed or molded into virtually any shape and reproduce any surface texture. It is the most widely used construction material in the world. In tonnage, worldwide concrete production is 10 times greater than steel production (Li *et al.*, 2022).

Concrete is a versatile construction material, adaptable to a wide variety of agricultural and residential uses. With proper materials and techniques, it can withstand many acids, silage, milk, manure, fertilizers, water, fire, and abrasion. Concrete can be finished to produce surfaces ranging from glass-smooth to coarsely textured, and it can be colored with pigments or painted. It has substantial strength in contraction, but is weak in pressure. Therefore underpinning of concrete is needed to allow it to handle tensile stresses (Tantawi, 1986) It is produced from a mixture of cement, fine aggregates and coarse aggregates using an appropriate mix design.

2.14.1 Cement

The purpose of cement is to bind the concrete. The American Society for Testing and Materials classifies Portland cement into five types.

I) Type I cement this is the standard general purpose Portland cement, and the most Common type of cement. It’s used when Sulphate exposure is minimum.

II) Type II cements used for concrete that may be exposed to a low Sulphate content similar as soils that contain a low attention of sulfate.

III) Type III cements used for operations that bear strength at an early age.

IV) Type IV cements used for operations that bear a fast setting time, similar as in heads and places that bear large quantities of concrete.

V) Type V cements these are the high Sulphate-resistant Portland cements, there are used in operations where concrete is exposed to a high attention of Sulphate, similar as seamster (Materials, 2001).

2.14.2 Water

In order to produce concrete, water is a necessary ingredient. It is crucial for the hydration of cement and is also used for washing during the extraction of aggregates, as quenching for GGBS (Ground Granulated Blast Furnace Slag) during the mixing and placing of concrete, for cleaning the plant, and in dust suppression measures (Su *et al.*, 2002).

About 15–18% of the total volume of concrete is made up of water; too much water decreases strength and durability, lengthens set times and shrinkage, and weakens the concrete's surface by causing dusting or flaking. The concrete will become unworkable and workers won't be able to properly finish it if there isn't enough water, though. Water accounts for 30% of all resources used in the production of concrete when process water is included (Bhattarai, 2019).

2.14.3 Aggregates

Around 75% of the volume of concrete is comprised of aggregates, making them a vital component of the production of concrete (Ogunbayo *et al.*, 2018) . Sand, gravel, crushed rock, recycled concrete; glass, limestone, and granite are just a few examples of the materials that can be used. The characteristics, mix proportions, and overall cost-effectiveness of concrete are significantly influenced by the aggregates, which make up 60 to 80 percent of its volume. Essentially silt- and organic-free, strong, and long-lasting are requirements for all aggregates (Naderi and Kaboudan, 2021).

2.15 Impact of Booming Concrete Production on Water Resources Worldwide

Currently, the production of concrete uses almost 10% of all industrial water used worldwide, and in 2012, it accounted for 9% of all industrial water withdrawals. In areas where water stress is anticipated, 75% of the water needed for concrete production in 2050 is likely to take place. Concrete producers must therefore use careful water management techniques and may need to enhance them further in order to protect their water supply and guarantee the production of concrete at a reasonable cost (Miller *et al.*, 2018).

2.16 Environmental Impact of Concrete Production

One of the most popular man-made materials is cement, and concrete is one of its most common uses. Because of their extensive use, cement and concrete production produce significant amounts of greenhouse gas emissions and put a strain on the availability of natural resources like water. Accordingly, the demand for cement and concrete is expected to rise over the next 50 to 100 years, necessitating the development of strategies to reduce their negative effects on the environment (Mohamad *et al.*, 2022).

According to estimates, in 2019, CO2 emissions associated with their use, transportation, production, and demolition will account for 10% of all energy-related CO2 emissions worldwide, which also include fuel combustion, power consumption, and carbonate (Olsson *et al.*, 2023).

2.17 Water Quality Standards

Acceptable Criteria for Questionable Water Supplies

The acceptable criteria for questionable water supplies are presented in table 2.1.

Table 2.1 Concrete Performance Requirement (ASTM, 2006)

Parameter	Standards	Limits	Provision/Remark
Compressive strength	ASTM C1602	≥90% of the mean strength of the control samples prepared with water from distilled or potable water	The mean 7day compressive strength of concrete made with mortar or concrete samples prepared with the water which must be controlled sample.

Table 2.1 above specifies that the concrete's compressive strength should be equal to or greater than 90% of the mean strength of the control samples prepared using distilled water or potable water**.** This table essentially sets a standard for the minimum strength performance of concrete when using specific types of water for mixing.

Table 2.2 Optional Chemical Limits for mixing water. (British-Standard, 2002; ASTM, 2006)

S/N	Parameters	Units	Standards	Limits
1	pH	---	BS EN 1008	≥4.0
2	TDS	mg/l	ASTM C1602	≤50000
3	Alk.	mg/l	ASTM C1602	≤600
4	Cl^-	mg/l	ASTM C1602	≤1000
5	SO_4	mg/l	ASTM C1602	≤3000

Non-potable water is defined by ASTM C1602 as water that is unfit for human consumption or includes contaminants that give it an unpleasant flavor or odor. As long as the water complies with specific requirements, it permits the use of non-potable water in the manufacturing of concrete. It also makes provision for the acceptable impurities and this is shown in table 2.2 above. To verify that the water used to make concrete satisfies the standards for contaminants, it must be tested. A certified laboratory must conduct the testing, and the findings must be recorded and maintained on file. It also states that regarding Quality Control, the engineer or architect in charge of the project must give their approval before non-potable water is used in the manufacture of concrete. To ensure that the concrete satisfies the necessary standards for strength and durability, it is imperative to regularly monitor the usage of doubtful water sources.

2.18 Reviews of Related Works

According to Asha *et al.* (2016), in order to treat the wash water gathered from car service stations, the efficacy of chemical and physical approaches was examined. Two service stations in Bangalore were used to collect wash water, and various parameters including pH, turbidity, conductivity, total solids, oil and grease, COD (chemical oxygen demand), BOD (biological oxygen demand), chlorides, sulfate, and total hardness were measured in the effluent. Alum was used for chemical treatment, and locally accessible natural resources like sawdust and sugarcane bagasse were utilized for physical treatment. The development of flocs was caused by agitating alum at various concentrations with the effluent for the required contact time. As filter columns with three different heights, the filtered samples were examined for COD and oil & grease. The depth and kind of filter material were connected to the percentage reduction in COD and oil and grease. Natural materials are effective at removing oil and grease and COD from the automotive effluent, and because they are environmentally friendly, they offer a feasible solution when compared to physical and chemical techniques of treatment. According to experimental investigations, any material's sorption capacity in physical treatment depends on its porosity, surface area, and filter bed height.

According to Mujumdar *et al.* (2020), it has been noted that a significant amount of water is consumed when washing cars, and the waste water produced by the operation is simply dumped into the local drainage system. Since the water used to wash cars is not too contaminated, it may be simply cleansed and utilized again to wash cars. The current work attempted to choose how to treat servicing center waste water and reuse the treated water for car washing, thereby reducing the consumption of fresh water. The Exotica Car Detailing

Studio in Ruikar Colony, Kolhapur, has been chosen as the study location. To determine the average content of these pollutants in car wash waste water, samples of the waste water were collected and the concentration of parameters such as pH, BOD, COD, TS, TDS, TSS, O and G examined. According to the findings, the car wash wastewater treatment was completed, and a lab-scale model incorporating five processes—collection, screening with O&G removal, chemical coagulation and flocculation, sedimentation, and filtration was constructed. For the criteria such as pH, BOD, COD, TSS, O & G, etc., the treated carwash wastewaters fulfill Environmental Protection Rules Discharge regulations as per Schedule VI 1986 to discharge the treated water onto the land surface or for irrigation. Thus, the treated water can be repurposed for car washing, reducing the need for fresh water, and discharged onto the same area to raise or sustain ground water levels.

According to Baddor *et al.* (2014), car wash facilities in Aleppo City have a harmful impact on the environment, contaminating the air, water, and soil. Treatment involved improving the vehicle wash water's quality to a point where it could be recycled, reused for the same purpose, and safely disposed of by recycling and beneficial use. To find the best conditions for removing all surface-active chemicals, total dissolved solids, and leftover oils and grease from car wash, laboratory tests were carried out on a sample taken from stations permitted in Aleppo's city center.

Torkashvand *et al.* (2022) explained that the main drawbacks of Carwash wastewater treatment procedures included low water recovery rates, quick and severe fouling, sludge generation, energy consumption, and unfavorable changes in effluent such a drop in pH and an increase in dissolved solids. Therefore, crucial elements of on-site treatment and reuse of

Carwash wastewater include short treatment times, maximum effectiveness, operational conditions, and high-water recovery ratios.

According to Mathurin *et al.* (2022), the primary objective of this study is to evaluate how the utilization of wastewater from soap production affects both the physical and mechanical characteristics of concrete. The experimental test scheme was devised to gauge the effects of altering the concentration of wastewater obtained from soap factories, which is being substituted for regular tap water. Various cylindrical concrete test specimens were created, with the proportion of soap factory wastewater ranging from 0% to 100%, based on water-to-cement ratios of 0.5, 0.6, and 0.7. These cylindrical samples were assessed at different time intervals (3, 7, 28, 60, and 90 days), applying a consistent load and automatically measuring breaking stress upon failure. The experimental outcomes suggest that substituting soap factory wastewater for tap water in concrete formulation leads to diminished values in concrete's subsidence at the Abrams cone, delays cement setting initiation, reduces compressive strength, and triggers early-stage pore formation in the concrete matrix. Quantitative correlations were established to gauge the strength loss in concrete.

According to Mathurin *et al.* (2022) whose primary focus was on characterizing car wash wastewater and its impact on concrete properties, analysis of chloride and sulfate presence in car wash wastewater was compared to ASTM standards (ASTM C33). Concrete property tests, including compressive strength, tensile strength, and modulus of elasticity, adhered to ASTM standards (BS 882, ASTM C192, and ASTM C143). The research investigated various replacement percentages of car wash wastewater (10%, 20%, 30%, and 40%) for tap water in concrete mixes, maintaining a water-cement ratio of 0.45. The concrete specimens aimed for a mean strength of 35 MPa using DOE method. Conclusions drawn from experimental results suggest that car wash wastewater's pH ranged from 8.8 to 10.6, slightly higher than tap water. However, sulfate and chloride content aligned with ASTM and BS standards. At 10% car wash wastewater, compressive strength, tensile strength, and modulus of elasticity decreased; 20% and 30% led to increasing values, but beyond 30%, the values declined. Higher compressive strength could indicate a higher modulus of elasticity. Based on compressive strength and modulus of elasticity outcomes, 20% car wash wastewater is recommended as a suitable fresh water replacement in concrete mixes.

Al-Jabri *et al.* (2011) conducted a study in Oman where automobile wastewater was utilized for concrete production. They assessed wastewater characteristics like pH, chloride, alkalinity, and sulfate content, attesting their alignment with ASTM norms. Mechanical tests on the concrete included assessing compressive strength, tensile strength, and a flexural test at day 28.The concrete blend involved auto marshland wastewater ranging from 25 to 100. Experimental issues indicated that the strength of concrete incorporating auto marshland wastewater was similar to the control blend.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

The automobile water sample was collected from two car wash sites in Ugbowo, Benin-city, Edo-State. It is known for being the location of the Ugbowo Campus of the University of Benin (UNIBEN), a public research university. The study area has been the subject of research on various topics due to its urban nature. In this case, the first site Wash way carwash with coordinates, N 6°23’31.66188”, E 5°36’55.404” and the second site was Edegbe carwash with coordinates, N 6°24’28.42704”, E 5°36’25.2738.

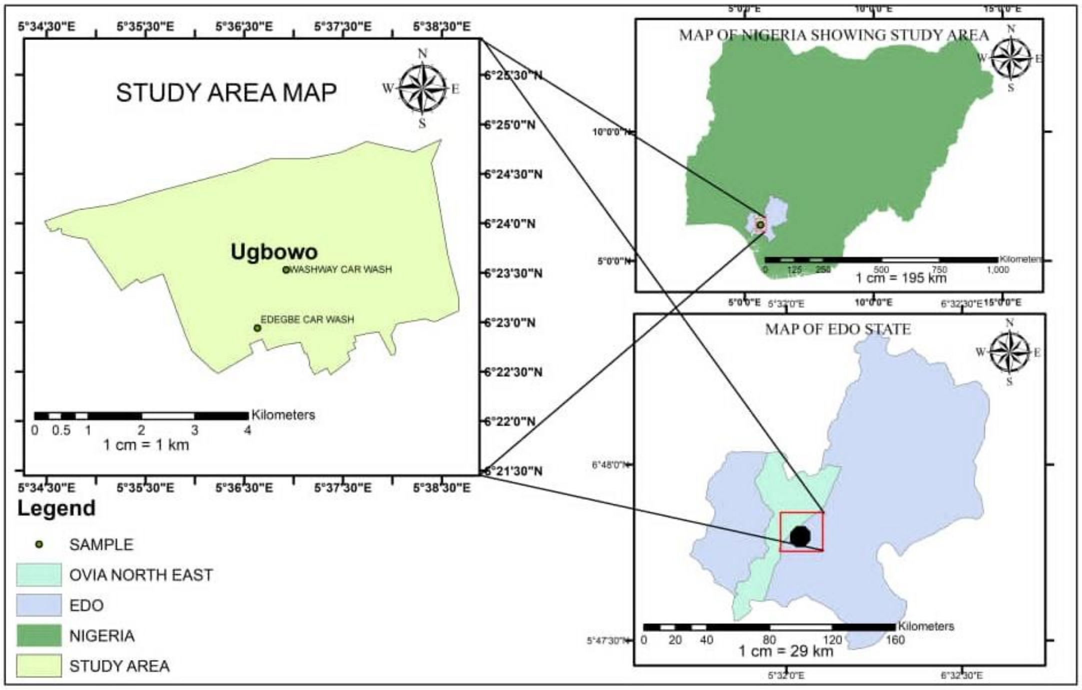

Figure 3.1: Map of Ugbowo, Benin City (Processed Image from ARCGIS)

3.2 Sample Collection

The wastewater sample was collected from two sites. The first two samples were collected at Wash way carwash (Sample site A) and the other two samples were collected at Edegbe Carwash (Sample site B). At Sample site A, automobile wastewater was collected through grab sampling either as the car was being washed or after the car was washed. In the process both the sample from the first wash and second wash of the car were collected in the sample bottle. The process was repeated until sufficient water needed for both laboratory testing and concrete production was obtained. At Sample site A, the samples obtained from the first wash were labeled, “AF” while the samples obtained from the second wash of the car was labeled as “AS”. The above processes were carried out as well at Sample Site B, with the samples obtained from both first and second wash labeled as, “BF” and “BS” respectively. Afterwards the samples meant were taken to the laboratory for testing.

taken to the laboratory for testing

Figure 3.2 Sample collection at sample site A

Figure 3.3: Sample Collection at Sample site B

Figure 3.4: Samples Collected

3.3 Material and Methods

3.3.1 Materials

Martlet Environmental Research Laboratory Limited was used to conduct the analysis. The analysis was conducted using a number of items, including equipment, reagents, and apparatus. The equipment utilized includes plastic bottles, different-sized Erlenmeyer flasks, measuring cylinders, micropipettes, volumetric flasks, burettes, funnels, stopwatches, ovens, electronic mills, filter papers, stirrers, and test tubes. The analysis of the samples was carried out in accordance to ASTM and APHA standards. A conductivity meter, atomic adsorption spectrophotometer and a potentiometric digital pH meter were also employed. The primary chemicals that will be employed are as follows: buffer solution, nitric acid (HNO_3), Pb $(NO_3)_2$, HCl, $KMNO_4$, and distilled water.

3.3.2 Source

Water samples was taken from Sample site A and Sample site B, sample was collected at the point of washing for the first and second wash. The automobile water sample was transported to the Macgil Engineering and Technical Services for physio-chemical and bacteriological examinations. The evaluation of the water samples was analyzed without treatment. The analysis results were compared. Additionally, the outcomes were evaluated against WHO guidelines and British water standard for construction.

The Automobile waste water samples were not treated before analysis. Prior to this, the plastic bottles were rinsed with 0.02M HNO_3 to maintain the constant pH and minimize loss of sample because of variation in PH, evaporation, precipitation and other relevant physical, biological and chemical properties. The sampling gallon was filled and then sealed tightly to avoid head space that could cause loss of samples because of oxidation. The physical, chemical and biological characteristics of the samples were analyzed according to American Standard for Testing and Materials (ASTM) and American Public Health Association (APHA).

3.4 Methodology for the Determination of Water Parameters

3.4.1 Determination of Phosphorus

Apparatus

i. 50ml volumetric flask

ii. 10ml pipette

iii. Spectronic 21D$^+$ Spectrophotometer

Reagents Preparation

i. Dissolve 12g of Ammonium Molybdate in 250ml of water

ii. In 100ml of water, dissolve 0.2908g Antimony potassium tartrate.

iii. 2.5M H_2SO_4: Make 872.7ml of conc. H_2SO_4 to 1liter.

iv. Add the ammonium molybdate and antimony potassium tartrate to 1000ml of 2.5ml H_2SO_4; mix thoroughly, make to 2000 ml and store in plastic container in a cool dark compartment.

v. Dissolve 0.53g of Ascorbic Acid in 200ml of reagent (P developer) (v) above. Prepare this mixture as required since it does not keep for more than 24 hours.

vi. 0.25 % p-Nitro phenol.

vii. Make 2M HCL by diluting 40ml of the 5M HCL in 100ml solution.

viii. 2M NH_4OH by diluting 13.6ml of conc. NH_3 solution in 100ml flask and make up to mark with water.

ix. Prepare a P-Standard Stock (100ppm) by dissolving 0.4394g of KH_2PO_4 in water and make to 1 litre.

x. Pipetting 0, 1, 2, 3, 4 and 5ml from the 100ml stock solution prepare intermediate standards of 0, 2,4,6,8, and 10ppm each in 50ml flask.

Procedure

i. Pipette 5ml of the sample into a 50ml flask.

ii. Adjust the pH to around 5: Add 3 drops of p-nitro phenol. If it turns yellow, add a few drops of 2M NH_4OH until it stays yellow. Then, add 2M HCL drop by drop until it turns colorless (pH between 3 and 5).

iii. Add water to bring the volume up to 30ml.

iv. Add 10ml of the Ascorbic Acid reagent.

v. Make up to the final volume, and read the absorbance at 660nm using the spectrophotometer.

Note

The colour is stable for 2 hours and maximum intensity is obtained in 10 minutes.

The Antimony Potassium Tartrate hastens the colour development and obviates the use of heating

Calculation

$$P(\text{ppm}) = \frac{\text{Instr. Reading} \times \text{Slop Recip.} \times \text{Colour Vol.}}{\text{Aliquot Taken}} \tag{3.1}$$

3.4.2 Determination of Total Hydrocarbons

Apparatus

i. 250ml separating glass funnels.
ii. Spectronic 21D$^+$ Spectrophotometer
iii. Spectrophotometer
iv. Pipette, 10ml
v. Mechanical Shaker

Reagents

i. n- Hexane
ii. Water

THC Standard Stock (1000ppm): Prepared by pipetting 1.18ml of Forcados Blend Crude Oil and making it up to 1 liter with n-Hexane. From this prepare 0, 10, 20, 40, 60, 80 and 100ppm working standards.

Procedure

i. Measure 50ml of the water sample into a 150ml separating funnel.
ii. Add 10ml of n-Hexane to the funnel.
iii. Shake the mixture manually for 2 minutes.
iv. Remove the stopper and allow it to settle for 20 minutes.
v. Drain off the water layer and collect the Hexane layer.
vi. Read the absorbance at 460nm using a spectrophotometer.

Calculation

THC (mg/l) = Instr. Reading x Slope Reciprocal x 25 x 20(water) (3.2)

3.4.3 Determination of Ammonium Nitrogen

Apparatus

i. 25ml volumetric flask
ii. 10ml Pipette
iii. Spectronic 21D$^+$ Spectrophotometer

Reagent

i. Alkaline Phenate: This is prepared by adding 200ml of phenol to 200ml of water, dissolving 200g of NaOH in 400ml of water, and allowing it to cool. The phenol solution is slowly added to the NaOH solution, making it up to 1 liter. This reagent should be used 24 hours after preparation.
ii. Sodium Potassium Tartrate: Prepared by dissolving 45g of Sodium Potassium Tartrate and 15g of Sodium Citrate in 200ml of water. Add 10g of NaOH, let it dissolve, and make it up to 300ml. It may need to be filtered before use, and it should be prepared fresh for each batch of analysis.
i. Sodium Hypochlorite or Bleach. (Use the concentration solution)
iii. Standard Ammonium (NH_4^+) Stock Solution (100ppm): Prepared by dissolving 0.3667g of pure dry $(NH_4)_2SO_4$ in water and diluting it to 1 liter.
iv. Working NH_4^+ Solution: Prepared by pipetting 0, 2, 4, 6, 8, and 10ml of the stock solution into 100ml flasks.

Procedure

i. Pipette 5ml of the filtrate from the Sodium Acetate extract into a flask.
ii. Add 2.5ml of Alkaline Phenol, 1ml Sodium Potassium Tartrate, and 2.5ml of Sodium Hypochlorite or Bleach to the flask. Shake well between each addition.
iii. Treat the standard solutions in a similar manner as the sample.
iv. Read the colorimetric absorbance at 636nm against the blank (usually water).

Calculation

NH_4^-N (ppm as mg/l) = IR x SR x Colour Vol. Aliquot taken (3.3)

3.4.4 Determination of Nitrate (No_3)

Apparatus

i. Spectronic 21D$^+$ Spectrophotometer
ii. 50ml volumetric flask
iii. 10ml pipette

Reagents

i. Brucine 2.5%: Dissolve 2.5% of Brucine or Brucine Sulphate in 100ml of Glacial Acetic Acid (very toxic; handle with care). Store in a dark place.
ii. Conc. H_2SO_4 (SG=1.84 and 97-99 % pure)
iii. Standard NO_3, 100ppm stock: Dissolve 0.16g of KNO_3 in water, add 0.5ml of Chloroform as a preservative and make to 1000ml.
iv. Working NO_3 Standard (10ppm) solution Prepared by pipetting 10ml of the stock solution into a 100ml flask and making it up to the mark with water. From this

solution take 0, 1, 2, 3, 4 and 5, each into 50ml flask to have 0, 0.2, 0.4, 0.6, 0.8 and 1.0ppm when made to mark after adding the colour developing reagents (Note: The 0 is the extractant for NO_3)

Procedure

i. Pipette 10ml of the filtrate from your water sample into a 50ml flask.
ii. Add 2ml of Brucine 2.5% to the flask.
iii. Then, add rapidly 10ml of concentrated $H_2SO_{4.}$ (Sulfuric acid).
iv. Mix well and let it stand for 10 minutes.
v. Treat the standards in a similar manner as the sample.
vi. After allowing it to stand, make the samples and standards up to the mark with water.
vii. Read spectrophotometrically at 470nm.

Calculation

Same as (3.3)

3.4.5 Determination of Nitrite

Apparatus

i. 50ml volumetric flask
ii. 10ml pipette
iii. Spectronic $21D^+$ Spectrophotometer

Reagents

1. 30% Acetic Acid
2. Sulphanilic Acid: Dissolve 1.6g of the acid in 200ml of 30% acetic acid. Gentle heat may be applied to aid dissolution.
3. Alph-Naphthylamine: Dissolve 0.5g Napthhylamine in 100ml of 30% acetic acid. Gentle heat may be applied to aid the dissolution. This reagent does not keep for more than a few days
4. Standard NO_2 Solution (100ppm): Dissolve 0.15g of the Naphthylamine in 100ml of 30% acetic acid. Gentle heat may be applied to aid the dissolution. This reagent does not keep for more than a few days.
5. Working NO_2 Solution (10ppm)
6. Pipette 10ml of the stock into 100ml flask and make to mark. From this solution, take 0, 1, 2, 3, 4 and 5ml each into 5ml flask to have 0, 0.2, 0.4, 0.6, 0.8 and 1.0ppm when made to mark after adding the colour-developing reagents, Note: the 0 is the extractant for NO_2.
7. 2M HCl: 40ml of 5M HCl in 1000ml solution.

Procedure

1. Pipette 10ml of the filtrate into a 50ml flask and add 2ml of 2M HCl, then dilute to about 30ml with water.
2. Add 2ml of Sulphanilic Acid stir and allow to stand for 5 minutes.
3. Treat the standards in a similar manner as the samples.
4. Add 10ml of Alpha-Naphthylamine, stir and make to volume.

v. Colour development occurs after a few minutes. Read the absorbance at 520nm after 20 minutes.

Calculation

Same as (3.3)

3.4.6 Determination of Sulphate (So4)

Apparatus

i. 50ml volumetric flask
ii. Spectronic 21D$^+$ Spectrophotometer
iii. 10ml pipette

Reagents

i. Gelatine
ii. Barium Chloride ($BaCl_2 .2H_2O$)
iii. Gelatine- $BaCl_2$ Reagent: Dissolve 0.6g of Gelatine in 200ml of hot water and allow to stand for 16 hours in a refrigerator. Bring out the Gelatine and let it attain room temperature and add 2g of $BaCl_2$; mix until dissolved. Store in a refrigerator. Bring it out and let it attain room temperature for 5 hours before use.
iv. Standard SO_4^{-2} Stock Solution (100ppm): Dissolve 0.5444g of anhydrous K_2SO_4 in water and make to 1 litre.
v. Working SO_4 Standard (10ppm)
vi. Pipette 10ml of the stock into 100ml flask and to make. From this solution, pipette 0,2.5,5.0,7.5,10.0 and12.5ml each into 50ml flask to have 0.5, 10.0, 15.0 20.0 and

25.0ppm when made to make after adding the colour-developing reagent. Note the 0 is the extractant for SO_4

Procedure

i. Pipette 10ml of the filtrate into a 50ml flask, add water to bring the volume to about 20ml.
ii. Add 1ml of the Gelatine – $BaCl_2$ reagent. Let stand for 30min, and make to mark with water. Mix well, treat the standard similarly.
iii. Read turbidity at 420nm in a spectrophotometer.

Calculation

Same as (3.3)

3.4.7 Determination of Chloride by Silver Nitrate Titration

Apparatus

i. 250ml conical flask
ii. 50ml Burette
iii. 10ml Pipette

Reagents

i. Potassium Chromate indicator (2% $K_2Cr\,O_7$)
ii. Standard $AgNO_3$, 0.05M: Dissolve 8.4936g of the salt in water and dilute to 1 litre.
iii. Standard Cl^- stock and working solution:
iv. See Section (b) (iv) and (v) of the Mercuric Thiocyanate Method.

Procedure

i. Pipette 10ml of the filtrate into a 250ml conical flask, add1ml or 3 drops of $K_2Cr\,O_4$. Titrate with standard 0.05M $AgNO_3$ until a slight red precipitate occurs.
ii. Treat the blank, 9ml of the K_2CrO_4 indicator and 10ml of 20ppm Cl^- as in step (ii) – (iii) above

OR

i. 50ml aliguot, then add 2 drops of phenolphthalein indicator. 2 drops methyl orange, 3 drops of 0.025M H2SO4 (to bring it to methyl orange endpoint). 1ml 2% Potassium Chromate. Then titrate with the 0.05M $AgNO_3$ solution, to obtain deep brown as end point.
ii. (0.05 x T x 35.5 x 1000/50 mg/L = 1775/50 = 35.5T)

Calculations

$$\text{Cl- (mg/ for water)} = \frac{\text{Molarity} \times \text{Titre} \times \text{Mol.Wt} \times 1000}{\text{Aliquot taken}} \quad (3.4)$$

3.4.8 Determination of Chemical Oxygen Demand (COD)

Apparatus

i. 250ml conical flask
ii. Reflux Condenser
iii. 50ml Burette
iv. 10ml and 50ml Pipette
v. Glass Beads

Reagent

1. $K_2Cr_2O_7$, 0.00833M
2. Dissolve 2.45g of the salt in water and dilute to 1 litre
3. $HgSO_4$
4. Ag_2SO_4: Dissolve 10g of the salt in 1 litre of conc. H_2SO_4
5. Ferroin Indicator: Dissolve 1.485g of Orthophenanthroline Monohydrate in 100ml of 0.025M Ferrous Sulphate (0.38g $FeSO_4$ per 100ml of solution)
6. 0.025M $Fe(NH_4)_2\ (SO_4)_2 6H_2O$: Dissolve 9.8g of the salt in water, add 5ml of conc. H_2SO_4 and dilute to 1 litre

Procedure

1. Pipette 50ml of water sample into a conical flask.
2. Add 10ml of the 0.00833 K_2CrO_7 solution.
3. Add 1g of $HgSO_4$ and 80ml of $Ag_2SO_4 – H_2SO_4$ solution and a few beads.
4. Fit a reflux greaseless condenser and heat gently to boiling and then boil for exactly 10 minutes. Leave to cool.
5. Rinse the condenser with 50ml of water and cool the flask under running tap.
6. Add two drops of Ferroin indicator and titrate with 0.025M $Fe(NH_2)_2\ (SO_4)_2 6H_2O$ until the colour changes from blue-green to red-brown.
7. Do a Blank Determination as above on 50ml of water

Calculation

The difference in value between the two Titres gives the Titre of the sample. That is 1ml of difference = 0.2mgDO or 4mgDO/L if a 50ml sample is taken. If 25ml is used T x 8mg/l O2/l

3.4.9 Determination of Turbidity

Apparatus

i. Spectronic 21D$^+$ Spectrophotometer
ii. Cuvette
iii. 10ml Pipette
iv. 100ml conical flask

Reagent

i. Dissolve 1g of Hydrazine Sulphate in water and dilute to 100ml
ii. Dissolve 10g of Hexamethylene Tetramine in water and dilute to 100ml
iii. Mix 5ml of each solution above in a 100ml flask and allow to stand for 24 hours at room temperature. Then dilute to the 100ml mark and mix well. THIS MIXED SOLUTION IS 400 FTU (IT SHOULD BE PREPARED MONTHLY).
iv. From the 400FTU, prepare 0, 10, 20, 30, 40, and 50 FTU as Working Standards in 50ml flasks

Procedure

i. Pour 25ml of water into the cuvette and read at zero in the spectrophotometer at 450nm

ii. Pour 25ml of the water sample into another cuvette and read in the meter
iii. Read the Working Standards similarly

Calculation

Turbidity (FTU) = Instr. Reading x Slope Recip. (3.5)

3.4.10 Determination of Colour

Apparatus

i. Spectronic 21D$^+$ Spectrophotometer
ii. Filter System

Reagents

Nil

Procedure

i. Rinse the filter by pouring 50ml of water through it. Discard the rinse water.
ii. Pour another 50ml of water through the filter. Fill a cuvette with 25ml of the filtered water and read the colour at 455nm.
iii. Pour 50ml of the water sample through the filter. Fill a second cuvette with 25ml of the filtered water sample. Read at 455nm.

Calculation

Colour of water in mg/l Pt.Co = Sample Colour – Water Colour. (3.6)

3.4.11 Determination of Suspended Solids in Water by Gravimetry

Apparatus

i. 250ml conical flask
ii. Filter paper, whatman No. 1
iii. Oven, 0 - 250°C

Reagents

Nil

Procedure

i. Dry a 15cm Whatman Filter Paper No. 1 50°C to constant weight (X1g)
ii. Filter, through the weighed paper, 100ml of water sample
iii. Dry in the same oven to constant weight a 50°C
iv. Weigh the filter paper with its content (X2g)

Calculation

Weight of Suspended solids = (X2 –X1) g (3.7)

Suspended solids (mg/l) = (X2 – X1) x1000x10 (3.8)

3.4.12 Determination of Conductivity/Total Dissolved Solids by A Meter

Apparatus

i. Conductivity/TDS Meter
ii. 100ml Volumetric flask

Reagent

i. 0.1M KCl: Dissolve exactly 7.4553g in water and make to 1liter
ii. 0.01M, 0.001M KCl: Prepare these from b (I) above

Procedure

i. Switch on the instrument by pressing power on, allow to stabilize for 10 minutes. Calibrate the conductivity by pressing CND and immersing the Probe in the KCl solutions above. Calibrate the TDS by pressing TDS and immersing the Probe in the KCl solution above. Rinse the probe and immerse in the sample solution:
ii. Read the Conductivity by pressing CND
iii. Read the TDS by pressing TDS.

Calculations

The meter reads the Conductivity and TDS directly in ms/cm or µs/cm and mg/l respectively.

3.4.13 Determination of Carbonate, Bicarbonate and Hydroxyl Ions (Alkalinity)

Apparatus

i. 250ml conical flask
ii. 50ml pipette
iii. 50ml Burette

Reagents

i. Phenolphthalein, 0.25% in 50% ethanol
ii. Methyl Orange, 01% in water

iii. H_2SO_4, 0.025M: 1.36ml of the conc. Acid made to 1 litre with water. (Standardize the solution with Na_2CO_3 or prepare from an ampoule).

Procedure

i. Pipette 50ml of the water.

ii. Add 3 drops of 0.25% phenolphthalein indicator.

iii. If a pink colour is obtained, titrate with 0.025M H_2SO_4 until colourless, to the colourless solution from the titration or to the original solution (if no colour is produced on adding phenolphthalein) add 3 drops of 0.1% Methyl orange endpoint. The solution may be reserved for chloride determination.

iv. Run Blank Determination with the reagents and CO_2^- free water with corrections made if found necessary.

Calculations

$$CO_3^{2-} + H_2SO_4 = CO_2 + H_2O + SO_4^{2-} \quad (3.9)$$

$$2HCO_3^- + H_2SO_4 = 2CO_2 + 2H_2O + SO_4^{2-} \quad (3.10)$$

$$2OH + H_2SO_4 = 2H_2O + SO_4^{2-} \quad (3.11)$$

From the equations,

$$1\text{mol } H_2SO_4 = 1\text{mol } CO_3^{2-} = 2 \text{ mols } HCO_3^- = 2\text{mols } OH^- \quad (3.12)$$

That is, Xmmols H_2SO_4 =Xmols CO_3^{2-} = 2Xmmolls HCO_3^- = 2Xmmols OH^-

Use the Table in next page for the calculations

The table below is used for calculating Alkalinity

Table 3.1 Titration Table for Alkalinity Determination

Result of Titration	**Titration Value Related to each ION**		
	Hydroxide	**Carbonate**	**Bicarbonate**
P = 0	0	0	T
P<1/2T	0	2P	T-2P
P=1/2T	0	2P	0
P>1/2T	2P-T	2(T-P)	0
P=T	T	0	0

P= Titration to the Phenolphthalein end point

T= Total Titration to the Methyl Orange end point

$$\frac{(\text{Molarity} \times \text{Titre} \times \text{Mol.Wt} \times 1000)\text{mg per litre}}{\text{Aliquot}} \qquad (3.13)$$

T x 61 = ppm $HCO3^{2-}$

3.5 Concrete Methodology

3.5.1 Sample Location and Sampling Collection

The sharp sand and coarse aggregate samples were collected and store in a used cement bags and transported to structural Laboratory University of Benin, Benin City, Edo State, Nigeria.

3.5.2 Materials

The following materials can be used as partial replacements for cement in concrete when employing mound soil and rice husk:

i. Coarse aggregate
ii. Fine aggregate
iii. Cement
iv. Water
v. Oil grease

3.6 Machines and Equipment Used During the Test

Here are various machines and equipment used during the testing of concrete to ensure that it meets the required standards and specifications. Some of the commonly used machines and equipment for testing concrete include:

i. **Compression testing machine**: This machine is used to test the compressive strength of concrete specimens. It applies a compressive force to the concrete sample until it fails, and the maximum force applied is recorded as the compressive strength of the concrete.

ii. **Slump cone:** This is a simple cone-shaped device used to measure the workability of fresh concrete. It is filled with fresh concrete, and the height of the cone is measured after the cone is lifted away. This measurement indicates the workability of the concrete.

iii. **Concrete mixers:** Concrete mixers are used to mix the ingredients of the concrete, including cement, aggregates, and water. There are various types of concrete mixers, including drum mixers, pan mixers, and twin-shaft mixers.

iv. **Vibrating table:** A vibrating table is a device used to consolidate concrete specimens, ensuring that there are no air voids in the sample. The table is vibrated at a high frequency, causing the concrete to settle and compact.

v. **Weighing machine:** A weighing machine is used to measure the weight of various components used in making concrete, such as cement, aggregates, and water. Accurate measurements are crucial for ensuring the correct proportions of ingredients in the mix.

vi. **Shovel**: A shovel is used for mixing concrete and transferring it from one location to another. It is important to use a clean shovel to avoid contamination of the mix.

vii. **Weighing pans:** Weighing pans are used to hold the materials being weighed on a weighing machine. They are designed to be lightweight and easy to clean.

viii. **Buckets:** Buckets are used to transport water and other materials used in making concrete. It is important to use clean buckets to avoid contamination of the mix.

ix. **Measuring cylinder:** A measuring cylinder is used to measure the volume of water and other liquids used in making concrete. They are typically made of glass or plastic and have clear markings to ensure accurate measurements.

x. **Hand towel:** A hand towel is used to clean equipment and surfaces used in making concrete. It is important to keep equipment and surfaces clean to avoid contamination of the mix.

xi. **Cube moulds:** Cube moulds are used to mold concrete samples for compressive strength testing. They are typically made of steel or plastic and come in various sizes.

xii. **Head pan:** A head pan is a tool used to transport sand, gravel, and other aggregates used in making concrete. They are designed to be carried on the head for easy transport.

3.7 Mix Design

The result of the Mix design for Grade 20 concrete is presented in table 3.2

Table 3.2: Mix Design for Grade 20 Concrete (Using Grade 42.5 Cement)

S/NO	ITEM	UNITS	Values
1	STAGE 1		
1.1	Characteristic strength	MPa	25
1.2	Standard deviation	MPa	8
1.3	Margin	MPa	13.24
1.4	Target mean strength	MPa	38.00
1.5	Cement grade		42.5
1.6	Aggregate type: coarse		Crushed
1.7	Aggregate type: fine		Uncrushed
1.8	Free water/cement ratio		0.54
1.9	Maximum free water/ cement ratio		NONE
2	STAGE 2		
2.1	Slump	mm	30 – 60
2.2	Maximum aggregate size	mm	20
2.3	Free-water content	Kg/m^3	190
3	STAGE 3		
3.1	Cement content	Kg/m^3	352
3.2	Maximum cement content (specified)	Kg/m^3	NONE
3.3	Minimum cement content (specified)	Kg/m^3	NONE
3.4	Modified free-water/cement ratio		NONE
4	STAGE 4		
4.1	Concrete density	Kg/m^3	2430
4.2	Total aggregate content	Kg/m^3	1888
5	STAGE 5		
5.1	Grading of fine aggregate		Zone 11
5.2	Proportion of fine aggregate	%	36
5.3	Fine aggregate content	Kg/m^3	680
5.4	Coarse aggregate content	Kg/m^3	1208
6	STAGE 6- Trial Mix quantities	100mm cube	
6.1	Water (kg)		190
6.2	Cement (kg)		352
6.3	Fine aggregate		680
6.4	Coarse aggregate		1208

The results from the concrete mix design is presented in table 3.3

The results from the concrete mix design is presented in table 3.3

Table 3.3: Result from Concrete Mix Design **Source: (COREN concrete mix design manual, 2012).**

Quantities	Cement (kg)	water(kg)	Fine aggregates(kg)	Coarse aggregates(kg)
Per m^3 to the nearest kg	352	190	680	1208
Ratio	1	0.54	1.93	3.43

The results of the final Mix design is presented in table 3.4

Table 3.4: Final Mix Design

Quantities	Cement (mm^3 x 10^6)	water (mm^3 x 10^6)	Fine aggregate (mm^3 x 10^6)	Coarse aggregate (mm^3 x 10^6)
Ratio	1	0.54	1.93	3.43
Per 100mm cube (modified)	0.352	0.19	0.68	1.208

3.7.1 Determination of the Mix Proportions

Decision on the mix proportions will depend on the required strength and other properties of the concrete. From the mix design, the derived ratio was 1: 1.93: 3.43 for cement, fine aggregate and Coarse aggregate.

3.8 Setting Time Test

The figure below illustrates the process of carrying out Setting Time Test

Figure 3.5: Setting Time Test

The setting time of cement refers to the time it takes for the cement paste to change from a fluid state to a solid state. There are two main types of setting times: initial setting time and final setting time.

Initial setting time: This is the time taken for the cement to begin losing its plasticity and becoming rigid after mixing with water. The standard initial setting time for ordinary Portland cement is around 30 minutes.

Final setting time: This is the time it takes for the cement to fully set and harden. The standard final setting time for ordinary Portland cement is approximately 600 minutes (10 hours).

These times can vary depending on factors like the type of cement, temperature, humidity, and other additives used. Setting time tests are conducted using standard methods, such as the Vicat apparatus test, to determine these times accurately.

3.8.1 Materials and Equipment Needed

1) Cement sample

2) Water (potable and carwash sample)

3) Vicat apparatus (including the Vicat needle)

4) Stopwatch or timer

5) Graduated glass plate

6) Trowels

3.8.2 Procedure for carrying out setting time test

The setting time of cement was determined using both potable water and automobile wastewater sample respectively and it was carried out in accordance with BS 1008 standard.

1) Prepare a cement paste by mixing a 400g of cement with 121ml of water (portable and carwash sample respectively)
2) With the aid of a stopwatch, note the time water touched the cement paste.
3) After adding 121ml of water to the cement, this mixture is thoroughly mixed with the aid of trowels to achieve a uniform consistency.
4) Place the prepared cement paste in a mold.
5) Start the test by gently lowering the Vicat consistency plunger and release the needle gently so that it just touches the surface of the cement paste until it penetrates the

cement paste to a depth of 5mm. If the consistency value fails to reach 5mm, repeat the process 1-5 again until 5mm is reached.

6) Remove the consistency plunger and replace with the initial setting time needle.
7) . Continue to lower the needle slowly until it penetrates the cement paste to a depth of 5 - 6mm from the bottom of the mold. Record the time when this value is obtained. This indicates the initial setting time.
8) After recording the initial setting time, replace the initial setting attachment with the final setting time needle.
9) Repeat the process by lowering the Vicat needle onto the cement paste.
10) This time, start lowering the needle as before but continue to do so until the needle fails to pierce the paste and make a distinct impression. The time when this is achieved indicates the final setting time.
11) Calculate and report the initial and final setting times in minutes, comparing the results of the portable water cement mix and that of the carwash sample cement mix.

3.9 Slump Test

The figure below illustrates Slump Test carried out in the Laboratory

Figure 3.6: Slump Test carried out at the Structural Laboratory, Uniben.

The slump test is a simple and widely used test to measure the consistency of freshly mixed concrete. It determines the workability of the concrete, which are important properties that affect the ease of handling and placing the concrete. The slump value indicates the consistency of the concrete, with a higher slump indicating a more workable and fluid mix and a lower slump indicating a stiffer and less workable mix. The test should be performed immediately after mixing the concrete to obtain accurate results. The test involves the following procedures carried out in accordance with BS 1008 standard:

i. Prepare a cone-shaped metal mold with a top diameter of 100mm, a bottom diameter of 200mm, and a height of 300mm
ii. Clean the mold and wet it with water to prevent the concrete from sticking to the surface.
iii. Place the mold on a flat, level surface and fill it with freshly mixed concrete in three equal layers.

iv. Compact each layer of concrete by rodding it with a standard rod or a tamping bar, applying 25 strokes for each layer.

v. Strike off the top of the mold with a straightedge or a trowel and remove any excess concrete.

vi. Lift the mold vertically and allow the concrete to settle and spread out freely.

vii. Measure the difference in height between the top of the mold and the highest point of the concrete. This difference is called the slump.

viii. Record the slump value in inches or millimeters and repeat the test for at least two more specimens.

3.10 Casting of Concrete

The figure below illustrates Concrete casting carried out in the Laboratory

Figure 3.7: Casting and Vibration of concrete moulds.

Casting of concrete is the process of pouring or placing freshly mixed concrete into a mold or formwork and allowing it to set and harden into a solid mass. It is important to follow proper safety procedures during the casting process, such as wearing protective clothing, using safety equipment, and handling tools and equipment with care. The success of the casting process depends on the quality of the formwork, the quality of the concrete mix, and the proper curing of the concrete. The following are the general procedures for casting concrete carried out in accordance with BS 1008 standard:

i. Prepare the site and the formwork by ensuring that the ground is level, clean, and compacted. The cube formwork should be constructed to the desired size and shape of the concrete element.
ii. Apply a release agent or form oil to the inside of the cube formwork to prevent the concrete from sticking to the surface.
iii. Mix the concrete ingredients in the correct proportions according to the design specifications. Use a concrete mixer or a batch plant to ensure a uniform mix.
iv. Pour or place the concrete into the cube formwork in layers, using a shovel, a bucket, or a pump. Consolidate each layer by using a vibrator, a tamping bar, or a roller to remove any trapped air and ensure good compaction.
v. Continue adding layers of concrete until the formwork is filled to the desired level. Level and smooth the surface of the concrete using a screed board or a trowel.
vi. Cover the concrete with a plastic sheet or a curing compound to prevent moisture loss and promote proper curing. The curing time depends on the type of concrete and the environmental conditions.
vii. After the concrete has cured, remove the cube formwork and finish the surface as desired by using a trowel, a float, or other tools. Allow the concrete to dry completely before applying any loads or stresses.

Table 3.5: Breakdown of Concrete Cubes to Be Casted

Duration (Days)	7	14	28
First Wash	3	3	3
Second Wash	3	3	3

After casting, the concrete was left in the moulds to set for 24 hours before remolding

3.11 Curing of Concrete

The figure below illustrates the process of curing concrete carried out in the Laboratory

Figure 3.8: Curing of Concrete cubes in Bucket using potable water.

Concrete must be "cured" in order to reach the necessary strength and durability after being freshly put, which requires sustaining moisture and temperature conditions. The long-term functionality and durability of concrete structures depend on proper curing.

Concrete's strength, durability, and resistance to cracking and shrinkage are all improved by proper curing. Additionally, it enhances the appearance and lessens the likelihood of surface flaws like scaling or spalling. Quality curing ingredients, effective curing process execution, and careful curing environment monitoring are all necessary for the curing process to be successful. The following are the general procedures for curing concrete carried out in accordance with BS 1008 standard:

i. Immediately after casting, cover the concrete with a moist, non-absorbent material such as plastic sheeting, burlap, or wet sand to prevent moisture loss.

ii. Maintain a uniform temperature of the concrete surface by protecting it from extreme temperature changes, such as direct sunlight, cold wind, or frost.

iii. Keep the concrete surface moist by spraying it with water or by using a wet cover material. Do not allow the concrete to dry out during the curing process.

iv. Ensure proper curing time by following the recommended curing period for the specific type of concrete and environmental conditions.

v. After the curing period, remove the curing material and allow the concrete to dry before applying any loads or stresses.

vi. Protect the concrete from damage during the curing process by avoiding heavy equipment, traffic, or other stresses on the concrete.

3.12 Compression Test on Concrete Cubes

The figure below illustrates how Compression Test was carried out in the Laboratory

Figure 3.9a: Testing the compressive strength of the concrete cubes

Figure 3.9b: Testing the compressive strengths of the concrete cubes

Compression test on concrete cubes is a standard test method used to determine the compressive strength of hardened concrete. The strength and durability of concrete structures are significantly influenced by the concrete cube's compressive strength, which measures the cube's capacity to withstand compression. The test should be conducted in a laboratory using the right tools and protocols, and the outcomes should be compared to the concrete mix design's stipulated strength requirements. The test involves the following procedures carried out in accordance with BS 1008 standard:

i. Cast three standard cubes of concrete from the same batch, using a mold of 100mm x 100mm x 100mm in size.

ii. Label each cube with a unique identification number or marking to keep track of the cubes and place the cubes in a moist curing environment at a temperature of 27°C (+/- 2°C) until they are ready for testing.

iii. After the curing period, remove the cubes from the curing environment and wipe them dry.

iv. Place each cube on the lower platen of a compression testing machine with the cast surface facing upward.

v. Align the cube with the center of the loading platen and adjust the machine to apply a gradually increasing load at a constant rate of 140 kg/sq.cm per minute.

vi. Record the maximum load applied to the cube at failure and calculate the compressive strength of the cube in megapascals (MPa) by dividing the maximum load by the cross-sectional area of the cube.

vii. Repeat the test for the other two cubes and calculate the average compressive strength.

CHAPTER FOUR

4.0 RESULTS AND ANALYSIS

4.1 Result from Water Analysis of Automobile Wastewater

Table 4.1 shows the chemical properties of Wastewater collected from the two sample sites.

Table 4.1: Chemical Properties of the Automobile Wastewater Samples.

Parameters	**Sample AF**	**Sample AS**	**Sample BF**	**Sample BS**
pH	9.1	6.7	8.8	6.6
TDS (mg/L)	1581	453	1531	390
TSS (mg/L)	3.8	1.9	3.1	1.0
NO_2 (mg/L)	0.143	0.082	0.132	0.063
NO_3 (mg/L)	0.901	0.410	0.813	0.380
Cl (mg/L)	177.3	141.8	159.5	109.5
P (mg/L)	0.170	0.083	0.140	0.072
SO_4 (mg/L)	3.31	1.45	2.651	1.23
HCO_3 (mg/L)	389.1	128.1	311.1	128.1
NH_4 N (mg/L)	0.821	0.45	0.651	0.370
Mg (mg/L)	8.70	1.73	6.13	1.40
Ca(Mg/L)	15.11	4.73	13.12	3.38
K(Mg/L)	1.74	0.61	1.55	0.55
Na(Mg/L)	4.33	0.94	3.90	0.80
COD(Mg/L)	164.8	34.4	57.8	34.4

Table 4.2 shows the minerals properties of the samples taken from both sample sites.

Table 4.2: Mineral Properties of the Automobile Wastewater Samples

Parameters	**Sample AF**	**Sample AS**	**Sample BF**	**Sample BS**
Turb (NTU)	1.8	0.8	1.3	0.5
Col. (Pt.Co)	2.5	1.0	2.0	0.8
Sal(g/L)	1.43	0.41	1.40	0.35
EC(μS/cm)	3167	908	3087	781
FE (Mg/L)	1.48	0.83	1.01	0.73
Mn(Mg/L)	0.66	0.28	0.53	0.21
Zn(Mg/L)	0.93	0.51	0.80	0.42
Cu(Mg/L)	0.30	0.17	0.27	0.15
Cr(Mg/L)	0.21	0.11	0.20	0.10
Cd (Mg/L)	0.13	0.07	0.11	0.04
Ni(Mg/L)	0.09	0.04	0.09	0.03
Pb	0.17	0.09	0.15	0.07
V	0.06	0.02	0.04	0.02
THC	1.41	0.83	1.33	0.71

Table 4.3 below gives a summary of the results of the chemical properties of the wastewater samples taken from both sites.

Table 4.3: Summary of the Laboratory Test Results on Automobile Wastewater

Parameters	**Limits**	**Sample AF**	**Sample AS**	**Sample BF**	**Sample BS**
TDS (mg/l)	≤50000	1581	453	1531	390
Cl^- (mg/l)	≤1000	177.3	141.8	159.5	109.5
HCO_3 (mg/l)	≤600	389.1	128.1	311.1	128.1
SO_4(mg/l)	≤3000	3.31	1.45	2.651	1.23
pH	≥4.0	9.1	6.7	8.8	6.6

From the table 4.3 above, three chemicals properties (TDS, Cl and HCO_3) had some of the highest concentration and from table 2.2 in chapter 2, important chemical limits were provided with which a comparison can be done to see if any of these limits were exceeded. Although the value of pH and SO_4 were not in high concentration, they were also provided for in table 2.2, hence their inclusion.

From table 4.3 above, these limits from table 2.2 were inserted for immediate comparison and it could be seen that none of these parameters which are known to have effects on concrete were exceeded. Thus, the water samples taken from both samples sites were within the standard limits and would not need further treatment in order to be used for concrete production.

4.2 Result of Setting Time Test

Table 4.4 below shows the result of the Setting time test carried out on cement using first wash.

Table 4.4: Initial and Final Setting Time for Molds Using First wash.

Setting Time	Mold 1 (min)	Mold 2 (min)	Mold 3 (min)	Av. Setting Time (min)
Initial	84	86	88	86
Final	240	256	248	248

The average Initial and Final Setting Time for wash sample-cement mix (first wash) are 86 and 248 respectively. Table 4.5 below shows the result of the Setting time test carried out on cement using second wash.

Table 4.5: Initial and Final Setting Time for Molds Made Using Second wash.

Setting Time	Mold 1 (min)	Mold 2 (min)	Mold 3 (min)	Av. Setting Time (min)
Initial	65	63	68	65
Final	211	202	212	208

The average Initial and Final Setting Time for wash sample-cement mix (second wash) are 65 minutes and 208 minutes respectively. Table 4.6 shows the result of the Setting time test carried out on cement using potable water

Table 4.6: Initial and Final Setting Time for Molds Using Potable Water

Setting Time	Mold 1 (min)	Mold 2 (min)	Mold 3 (min)	Av. Setting Time (min)
Initial	108	113	116	112.3
Final	223	213	212	216

The average Initial and Final Setting Time for control-cement mix are 112.3 and 216 minutes respectively.

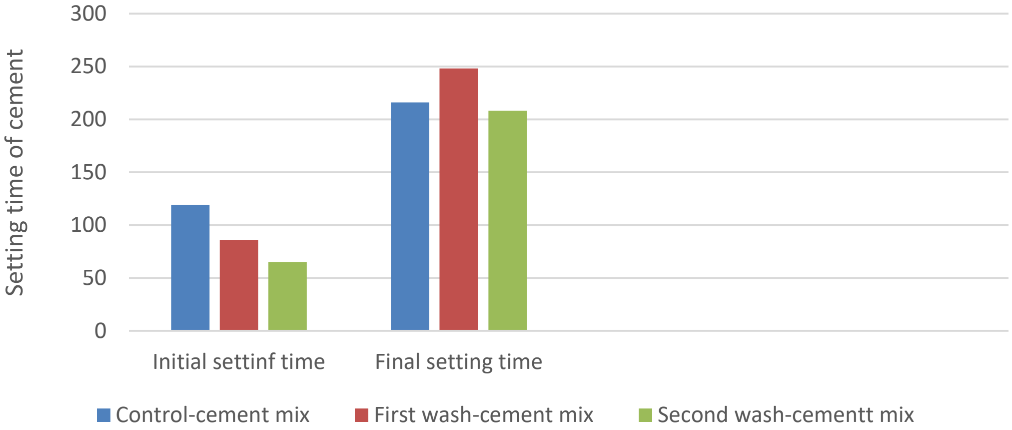

Figure 4.1: Graphical Representations of Results from Setting Time Test

From Figure 4.1 above, it can be seen that the initial setting time of the molds made using both the first wash and second wash experienced a decrease of 27.73% and 45.38% respectively in comparison to that of the control-cement mix. However, the Final setting time of the molds made using the first wash experienced an increase of 14.81% while that of second experienced a decrease of 3.70%. This means that the former experienced a longer setting time than the latter and this could be due to the fact that the composition and concentration of the first wash and second wash differs. From table 4.2, it is obvious that the first wash is alkaline (9.1) while the second was is acidic (6.7) An increase in the alkali content of cement delayed the time of final setting, reduced the compressive strength, and increased the rapid loss of workability (Li *et al.,* 2016) This explains why the final setting time of the cement mold made using the alkaline first wash experienced more delay than that of the first wash.

4.3 Result of Slump test

Table 4.7 shows the result of the slump test carried out on the concrete mix.

Table 4.7: Slump Test Results

Water Type	Slump Value(mm)
Potable water	10
First wash	18
Second Wash	15

The slump test carried out using Automobile wastewater yielded a slump of 18 and 15mm for first and second wash respectively as opposed to slump value from the control. From table 4.7 above it can be seen that the slump values correspond with the degree or concentration of detergents in the water type used for the test. Since first wash contains more detergent, its slump value was higher than that of second wash which contains a lower concentration of detergents.

4.4 Results from Compression Test

Table 4.8 shows the results obtained after using potable water in casting the concrete cubes.

Table 4.8: Compression Test Result using Potable Water.

Days	**Sample**	**Weight (kg)**	**Density of cubes (kg/m^3)**	**Failure load (KN)**	**Compressive strength (N/mm^2)**	**Average density (kg/m^3)**	**Average compressive strength (N/mm^2)**
7	W_1	2.56	2560	213.07	21.31	2553.333	19.53
	W_2	2.56	2560	193.25	19.33		
	W_3	2.54	2540	179.59	17.96		
14	W_1	2.54	2540	210.35	21.04	2550	21.52
	W_2	2.53	2530	229.73	22.97		
	W_3	2.58	2580	205.64	20.56		
28	W_1	2.57	2570	236.32	23.63	2576.67	23.14
	W_2	2.57	2570	228.22	22.82		
	W_3	2.59	2590	229.74	22.97		

Average Compressive Strength after 28 days for 100% fine aggregate and 100% potable water.

= (19.53+21.52+23.14)/3=64.19/3 = 21.40KN/m^2

Table 4.9 shows the results obtained after using first wash in casting the concrete cubes.

Table 4.9: Compression Test Result using First Wash

Days	Sample	Weight (kg)	Density of cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	W_1	2.49	2490	135.30	13.53	2473.33	12.77
	W_2	2.40	2400	108.89	10.89		
	W_3	2.53	2530	138.88	13.89		
14	W_1	2.44	2440	98.47	9.85	2463.33	9.43
	W_2	2.39	2390	91.83	9.18		
	W_3	2.56	2560	92.73	9.27		
28	W_1	2.51	2510	148.88	14.89	2496.33	14.82
	W_2	2.52	2520	156.90	15.69		
	W_3	2.45	2450	138.66	13.87		

Average Compressive Strength after 28 days for 100% fine aggregate

= (12.77+9.43+14.82)/3=37.03/3 = 12.34 KN/m^2

Table 4.10 shows the results obtained after using second wash in casting the concrete cubes.

Table 4.10: Compression Test Result using Second Wash

Days	Sample	Weight (kg)	ρ of cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	W_1	2.59	2590	89.82	8.98	2563.33	8.74
	W_2	2.57	2570	83.59	8.36		
	W_3	2.56	2560	88.92	8.89		
14	W_1	2.46	2460	114.49	11.45	2496.67	11
	W_2	2.51	2510	103.10	10.31		
	W_3	2.52	2520	112.39	11.24		
28	W_1	2.38	2380	84.42	8.44	2480	10.47
	W_2	2.71	2710	121.38	12.14		
	W_3	2.35	2350	108.29	10.83		

Average Compressive Strength after 28 days for 100% fine aggregate

= (8.74+11+10.47)/3=30.21/3 = 10.07 KN/m^2

Table 4.11 gives the summary of the compressive strengths of the concrete cubes casted using potable water, first wash and second wash respectively.

Table 4.11: Summary of Compressive Strength Tests

Water Type	7days(N/mm^2)	14days(N/mm^2)	28days(N/mm^2)
Potable water	19.53	21.52	23.14
First wash	12.77	9.43	14.82
Second wash	8.74	11.00	10.47

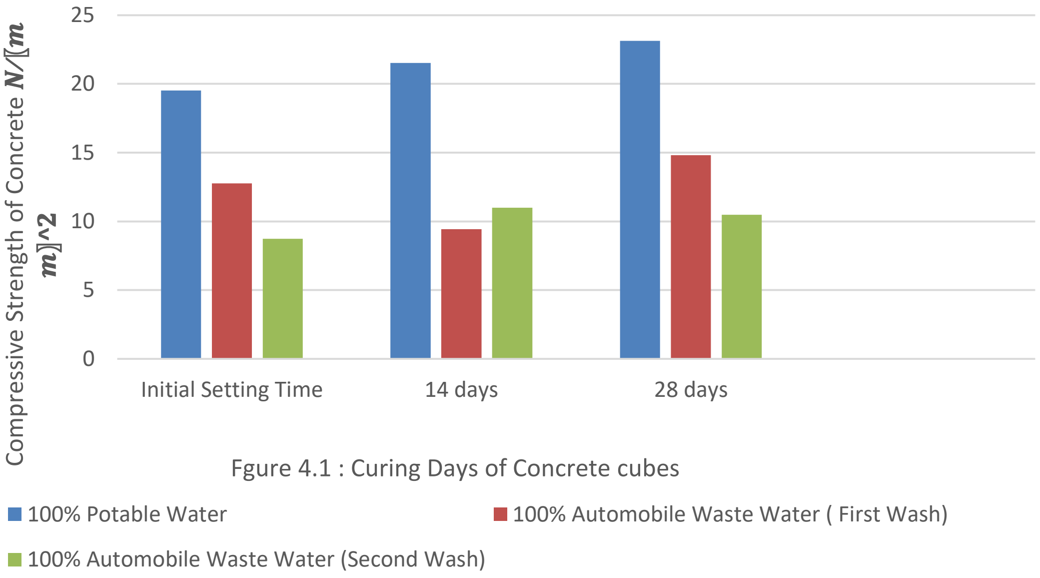

Figure 4.2: Graphical Representation of the Compressive Test Results

From the results obtained and analyzed, the average compressive strength of the concrete decreases with increase in potable water to 100% automobile wastewater. The compressive strength tends to decrease with the replacement of the potable water which is represented on figure 4.2 above.

From table 4.11 above, comparing the value of 100% automobile wastewater at first and second wash with nominal values of concrete produce with potable water, there is drastic decrease in compressive strength, it can be seen that at 7days, the percentage decrease of concrete strength at Nominal compressive strength against first wash is seen to be 34.61% and against second wash it is seen to be 55.25%. For 28days, the percentage decrease of concrete strength of Nominal compressive strength against first wash is seen to be 35.96% and against second wash it is seen to be 54.75%.

From the graph in figure 4.1, it is evident that the compressive strength of concrete at 100% automobile car wash for first wash is higher than second wash. It is important to note that the concentration of detergent for the first wash is more than that of the second. Which means that we have more of detergent which containing different chemical constituents and this is not good for concrete production in the first wash than in the second. Ordinarily, it is expected that the second wash should yield more positive results than the second wash, which is not the case in the course of the experiment.

Comparing the results in table 4.11 to the standard provided in table 2.1 in Chapter 2 which gives a limit of ≥90% of the mean strength of the control sample, the compressive strength of the cubes casted from the first wash yielded 65.38% while that of the cubes casted from the second wash yielded 44.74%.

Hence, from the above discussion, it is seen that automobile waste water is not suitable for concrete production. It must undergo process of treatment for more suitable results.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the results obtained from this study, it can be seen that the objectives of this study was achieved since we were able to assess the quality, composition and characteristics of automobile wastewater generated by the automobile industry while focusing on key contaminants and their concentrations.

From the laboratory analysis carried out on the samples taken, we were able to determine that water sample met the requirements and standards provided in table 2.2 in Chapter 2, thus making it of good quality for concrete production.

However, after the process of concrete casting, the compressive strengths of the cubes casted with first wash and second wash yielded poor results, as none of the results were up to 90% of the compressive mean strength of the control cubes at 7 days (as stated in table 2.1 in chapter 2).

This shows that utilizing automobile wastewater as a constituent in concrete production was not feasible and this could be due to the fact that at the stage when these samples were tested for before use, it may have been suitable for construction but due to the decaying properties of waste water, it may have yielded adverse effects in the concrete cubes overtime.

It can then be concluded that the wastewater generated from Automobile washes should undergo treatment for a more suitable result.

5.2 Recommendations

From the conclusion drawn above, the following recommendations can be made:

i. Further study on how these wastewaters generated from Automobile washes can be treated should be carried out.
ii. The experiment should be carried out again after treatment of the Automobile wastewater has been carried out to achieve a more suitable result.
iii. The findings of this study could serve as a catalyst for promoting sustainable water use, reducing environmental impact, and improving the efficiency of wastewater management practices in multiple industries, not limited to construction.

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