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Aims and Scope

Journal of Civil Engineering and Technology Research intended to bring together the information in different areas of civil engineering around the world. The aim of this journal is to combine theory and practice in civil engineering and thus advancement of civil engineering sciences. It will provide a platform for academicians, researches and engineers to share their experience and solution to problems in different areas of civil engineering.

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Contents

Use of plastic waste in bituminous road construction

Narender Taneja, Naval Kishore, Manoj Siwach and Deepak Kaushik

ABSTRACT

Plastic waste is one of the resources of which a major part of solid waste that is available in bulk and is disposed of without properly treating it. There has been an epidemic growth in the plastic waste disposal by the municipality especially in urban areas that decline the beauty of the land. Plastic is found to be one of the most effectively unite bitumen mixes used in the pavements. The main objective to use of waste plastic is to reduce plastic waste and improve the durability and sustainability of road infrastructure. It can also make the roads more resistant to wear and tear. In this paper it is recommended/presented to use the plastic waste materials in the road construction. 6% plastic waste with 60/70 grade of bitumen modification showed maximum stability in Marshall Stability test which represent high loading capacity of road due to increased brittleness of the road.

Keywords: Bitumen, PVC, Marshall stability

Introduction

In India, the issue of waste plastic has become a pressing environmental problem due to the vast quantities of non-biodegradable plastics being generated and improperly disposed of. With a rapidly growing population and increasing urbanization, there has been a significant rise in the production and consumption of plastic goods, leading to massive amounts of plastic waste clogging landfills, waterways, and public spaces. The lack of effective waste management infrastructure exacerbates this issue, resulting in harmful environmental impacts such as soil contamination, water pollution, and harm to wildlife. Furthermore, burning plastic waste releases toxic chemicals into the atmosphere, contributing to air pollution and posing health risks to nearby communities. Addressing the problem of waste plastic in India requires comprehensive policies for reducing plastic usage, improving recycling and waste management systems, and promoting sustainable alternatives to nonbiodegradable plastics. Polymer modified bitumen (PMB) is a type of bituminous binder utilized in the construction of flexible roads to enhance their performance. By adding polymers such as styrene-butadiene-styrene (SBS) or atactic polypropylene (APP) to bitumen, PMB exhibits improved flexibility, elastic recovery, fatigue resistance, and temperature susceptibility compared to traditional bitumen. This modification results in a more durable road surface that can better withstand heavy traffic loads and adverse weather conditions, reducing rutting and cracking over time. The enhanced properties of PMB also allow for thinner pavement layers, reducing material consumption and construction costs while maintaining high performance levels. Overall, the incorporation of polymer modified bitumen in flexible road construction leads to longer-lasting infrastructure with superior mechanical properties and improved overall performance.

Literature review

We have studied various literatures related to plastic, polymer modified bitumen, flexible road performance and etc. Some important literatures are as followings:

V. S. Punith and A. Veeraragavan (2007)[22]are described that viability of using reclaimed polyethylene (PE) derived from low-density PE carry bags collected from domestic waste as an additive in asphalt concrete mixtures. Different ratios of PE (2.5, 5.0, 7.5, and 10% by weight of asphalt) were blended with (80/100)-paving grade asphalt. The dynamic creep test indirect tensile test, resilient modulus test, and Hamburg wheel track tests were carried out on asphalt concrete mixtures blended with PE. The rutting potential and temperature susceptibility can be reduced by the inclusion of PE in the asphalt mixture. A PE content of 5% by weight of asphalt is recommended for the improvement of the performance of asphalt concrete mixtures similar to that investigated in this study.

Milad A. et al., (2020) [23] described that using waste materials in road construction is of great interest as their utilization may contribute to reducing the problems of hazard and pollution and conserve natural resources. Thus, there is an urgent need to find a sustainable method for using waste materials as a substitute in the standard asphalt binders. There are several concerns about the physical and chemical properties and mechanical performance of asphalt pavements incorporated with waste material in the effort to reduce permanent deformation of the road surface.

Fig 1: Various form of Plastic

Kurmadasu Chandramouli et al. (2016) “Plastic waste: its use in the construction of roads” reported that asphalt concrete using polyethylene modified binders were more resistant to permanent deformation at elevated temperature and found improvement in stripping characteristics of the crumb rubber modified mix as compared to unmodified asphalt mix.

After going through all the referred research papers, I found that the use of waste plastic in making of road and flexible pavement shall open up the solution for the disposing issues regarding the waste plastic. The coating of plastic may lessen the soaking of moisture, porosity and improves the correctness. The aggregate bitumen mix coated with the polymer forms a better material for use in the flexible pavement. Thus, the using of plastic waste for the flexible pavement is the best method for disposing of the waste plastic.

Objective

The broad objectives of this study are as under:

- Utilize waste plastic in flexible road construction.
- Plastic waste management.
- Increase performance of polymer modified bituminous all-weather roads.

Methodology and Design

To study the effect of mixing plastic waste in bituminous mixes, the following methodology was adopted. Four phases are involved to modify virgin bitumen with waste plastic which are as under.

Segregation: Plastic waste collected from various sources is separated from other wastes.

Fig 2: Segregation

The process of shredding plastic involves feeding plastic materials into a machine that breaks them down into smaller, uniform pieces. This is typically done to facilitate the recycling process, as shredded plastic is easier to transport and sort. Shredding also helps to reduce the volume of plastic waste, making it more manageable for storage and disposal. Additionally, shredding can help protect sensitive information on items such as credit cards or documents by destroying them beyond recognition. Professional shredding services use industrial-grade equipment that ensures thorough and precise shredding of plastics, leading to higher efficiency and better outcomes in the recycling industry

Cleaning: Plastic waste is cleaned and dried.

Fig 3: Cleaning

Shredding: Plastics will be shredded or cut into small pieces.

Fig 4: Shredding of plastic

Wet Mixing with bitumen

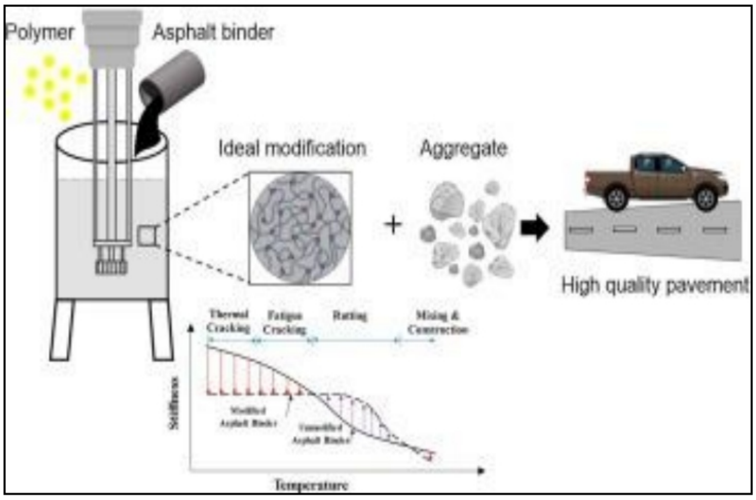

Fig 5: Polymer Modification

The plastic waste like carry bags, Polyethene etc. was collected and shredded to size passing through 2.36 mm sieve and retained on 600-micron sieve. The shredded plastic waste was mixed in the hot aggregates. Normal mix specimens were prepared with bitumen contents of 4.5%, 5%, 5.5% and 6%. The Optimum Bitumen Content (OBC) was found out using Marshall test. Plastic modified mix specimens with plastic contents of 6%, 8%, 10%, 12% and 14% by weight of bitumen were prepared through dry process by

adding plastic to heated aggregates. Marshall Test was conducted on plastic modified mix specimens to study different parameters. Processing of plastic waste and their use in road construction.

Conclusion

The following point wise conclusions are drawn from this research are as under

So, turns out mixing plastic with bitumen for roads isn't just some crazy idea - it actually works pretty damn well. When you think about it, plastic is already super durable, so adding it to bitumen just kicks things up a notch in terms of strength and longevity. Plus, using recycled plastic helps reduce waste and is way eco-friendlier than straight-up throwing it in a landfill. The end results? Roads that last longer, can withstand heavier traffic loads, and are even more resistant to wear and tear. Seems like a no-brainer to me! So yeah, next time you're cruising down the highway, take a second to appreciate the merit of plastic-infused roads - they're paving the way for a greener future one mile at a time.

Acknowledgment

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Conflicts of Interest: The authors declare no conflict of interest.

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Taguchi statistical analysis of the damage tolerance of natural fibre reinforced composite for hockey stick application

Nwambu CN, Iyebeye KO, Ajimatanrareje GA, Onyedikachukwu DE and Ekwedigwe CM

ABSTRACT

This paper experimentally investigated the damage tolerance of hybrid composite structures containing different concentrations of Banana fibre (BF) and Sponge Gourd fibres (SGF) for Hockey stick application. The weight percent of 5, 10, 20 and fibre sizes of 150 µm, 300 µm and 600 µm were used in this research. The design of the experiment was done via Taguchi's robust design. `The effects of hybrid concentrations on the damage tolerance were also investigated. The optimisation model of natural hybrid composite demonstrated excellent damage tolerance at different concentrations of the reinforcements with maximum hardness and impact strength obtained at 5%wt BF + 5%wt SGF sample and 10% wt BF + 10%wt SGF sample with fibre size of 300 um. The model explains 87.4% of impact strength variability, with a predicted R-squared value of 91.07%. The experimental result collaborated with the optimized results as the natural hybrid composite samples recorded higher damage tolerance than the sample with only epoxy resin. The improvements in mechanical properties are guaranteed by the distribution of BF and SGF in the epoxy resin matrix as evidenced in the microstructural analysis.

Keywords: Taguchi analysis, impact strength, hardness strength, natural fibre, fibre size

Introduction

The sports industry is an ever-growing sector all around the world. With technological advancements in information technologies, the sports industry has merged with and become a significant entertainment industry reaching and influencing billions of people globally (Nwankwo et al., 2023) [17]. However, in order to ensure and advance the safety, security, and sustainability of the sports industry, technological innovations are always needed in the manufacturing and materials processes to attain cost-effectiveness, efficiency, durability, reusability, and recyclability of the products used in this industry. Countries like China and India fabricate and export field hockey products, but around 90% of hockey equipment in the world is produced in Sialkot, Pakistan (Torres, 2019) [8]. Businesses are investing in the research and development of processes and materials to compete in the international market with economic and quality products. Most export quality field hockey equipment is currently produced via reinforcement of glass/carbon fibres in epoxy resin, composites usually have two different phases at the microscopic scale and it is essential to determine these integrant. Constituents with inferior physical and mechanical properties (the matrix) are combined with constituents having superior mechanical properties (reinforcement). Fibre-reinforced plastics possess some superior mechanical properties, including density, stiffness, and strength. These would unquestionably be the design drivers for the selection of materials in transportation (Matthews, et al. 2000) [5], sports, medical, construction, and packaging industries, as well as in consumer applications. Increased demand for materials with a high strength to weight ratio has led researchers to develop novel materials. Although synthetic fibre-reinforced polymer composites have significant mechanical strength, they also have some genuine drawbacks like comparatively high costs, high density, poor recycling, and non-biodegradable properties. Consequently, there have been significant developments in recent years in the use of natural fibre-reinforced composites. Natural fibres are being considered as a tenable substitute to synthetic fibres as they offer many advantages, including low cost, low density, biodegradability, reusability, and recyclability (Mohanty, 2004; Ekwedigwe et al., 2023) [6].

Several authors found that to enhance the properties of composites reinforced with natural fibres; they can be mixed with other conventional fibres to produce hybrid composites with superior properties (Venkateshwaran et al. 2011, Ekwedigwe et al., 2023; Okoye et al., 2023) [9, 13, 14]. Weed et al. 2014 [22] reported that banana fibre-reinforced composites had comparatively weak bonding between fibre and matrix. Jacob et al. 2005 [3] observed that banana fibres had a hydrophilic nature, and there was weak bonding between the matrix and fibre when the banana fibre was combined with the hydrophobic matrix. Therefore, researchers have reported the standard methods for the improvement of fibre and matrix bonding (Paul et al. 2008, Li et al., 2007) [11, 18]. Consequently, better bonding between the matrix and the fibre was achieved, and the material was improved mechanically courtesy of the presence of additional reinforcing material (Nwambu et al., 2023) [12]. In the recent times, the use of natural fibres for reinforcement in polymer composites has increased (Singleton, 2003; Nwambu et al., 2023; Ekwedigwe et al., 2023) [19, 12, 6]. Al Rashid et al. 2020 [1] studied the utilization of banana fibre reinforced hybrid composites in the sports industry, where the hybrid composite was the mixing of natural fibre with synthetic fibre (glass), they observed that the tensile properties and percentage elongation of the composite achieved an improved properties. However, the Taguchi statistical analysis of the damage tolerance of natural fibre reinforced composite for Hockey Stick application have not been reported. To this end the current work has undertaken to introduce novel materials for field hockey products, and also to reduce manufacturing costs and enhance environmental-friendly product, without compromising product quality.

Experimental Procedure

In this study, authors used banana fibre and the sponge gourd fibre sourced locally from the bush in Aguata Local Government Area, Aguata, Anambra State, Nigeria; the epoxy resin and the hardener used were bought from Victor Chemicals located in Lagos state, Nigeria. The banana and sponge gourd fibres were prepared separately and independently. The banana fibre was soaked in water for 24hrs so as to remove any dirt or debris from the fibre and thereafter sun dried for 2 days.

Afterward, degumming, removal of lignin, wax and optimum fibre roughness was achieved by soaking the dried banana fibre in 10% concentration of NaOH solution for 24hrs as reported by Cao et al., (2006) [2]and Vidyashi et al.

(2019). The alkaline treated fibre was thereafter continually rinsed with water until a pH value of 7 was obtained so as to obtain a neutral solution of the fibre. The rinsed fibre is sun dried again for 2 days before subjecting to methanol treatment where the fibre was soaked in a dilute methanol solution (60:40) for 3hrs which help in further increasing the fibre roughness and bonding properties of the fibre. The methanol treated fibre was subsequently sun dried for 2 days, after which the fibre is ready for pulverization. These procedures were also repeated during the preparation of sponge gourd fibre. The surface area of the fibres (Banana and sponge gourd) was increased by pulverization technique, which converts the long grain fibres to a powdered form. The particle size analyses of the pulverized fibres were carried out in accordance with ASTM-60. 200g of the fibre particles were placed into a set of sieves arranged in descending order of fineness and electrically shaken for 15 minutes which is the recommended time to achieve complete classification. The weight retained on 150 µm, 300 µm and 600 µm were used in this research. The wt% of the fibres (Banana and sponge gourd), polymer was measured accordingly via an air tight electronic weighing balance from the data analysis obtained from the design of experiment using Taguchi.

Heating of the paraffin wax to its melting point (50 °C) was done with the help of a Bunsen burner; afterward the liquid wax was immediately sprinkled on the metal mould before casting. This was done to enable easy removal of samples from the metal mould. After waxing the mould, the composite materials (wt % of banana, % wt of sponge gourd, polymer and hardener) were mixed in a crucible plate and stirred continuously using a stirrer until a uniform mixture was obtained.

The mixture was subsequently poured into a 300mm × 300mm waxed metal mould and allowed to set; the design formation was used in the production of the composite. Experiments were carried out under standard environmental conditions in the laboratory.

The design of the experiment was done via Taguchi robust design which involves reducing the variation in a process through robust design of experiments. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varied. Instead of having to test all possible combinations like the factorial design, the Taguchi method tests pairs of combinations. This allows for the collection of the necessary data to determine which factors most affect the product quality with a minimum amount of experimentation, thus saving time and resources.

$$\text{Signal to noise ratio for the higher the better} = -10log\sum\frac{y^{-2}}{n}$$

Where, n = No. of observations

R = Observed data for each response

Three superplastic forming parameters are considered as controlling factors. They are % wt of fibre 1 (Banana), % wt of fibre 2 (Sponge gourd) and fibre particle size. Each parameter has three levels as shown in Table 1.

Table 1: Factors and levels

Factor	Level
Wt % of banana (A)	3
Wt % of sponge gourd (B)	3
Fiber size (C)	3

The impact testing of the composite samples was conducted using Avery dension test machine. Charpy impact tests was conducted on the samples with 100mm ×20mm ×5mm dimension in accordance with ASTM D256-10 standard test method for determining the chary pendulum impact resistance of plastics. Before the test, samples were mounted on the machine; the pendulum was released to calibrate the machine. The test samples were then gripped horizontally in a vice and the force required to break the bar was released from the freely swinging pendulum. The value of the angle through which the pendulum swung before the test sample was broken correspond with the value of the energy absorbed in breaking the sample and this was read from the calibrated scale on the machine.

The hardness testing of the samples was performed using Leeb hardness tester at the department of Metallurgical and Materials Engineering, University of Nigeria, Nsukka, Enugu State. Leeb hardness testing was conducted on the samples with 20mm×20mm×20mm dimensions according to ASTM A956 standard, prior to the test, the samples were mounted on the anvil, and then the impact device accelerates an impact body using spring force. Thus, the ratio of rebound velocity Vr to impact velocity Vi, multiplied by a factor of 1000 gives the Leeb hardness.

$$HL = \frac{\text{Rebound velocity}}{\text{Impact velocity}} \times 1000$$

Thereafter Leeb hardness results in HL are converted to traditional hardness scale HR (Hardness according to Rockwell) from classified hardness chart.

Results and Discussion

Impact Strength

Figures 1 and 2 showcase the impact of different sample compositions (A to I) at each of three fibrezes

(150 µm, 300 µm, and 600 µm) on the impact strength of composite materials.

At fibre size 150 µm Sample C (20% banana + 5% sponge gourd) exhibits the highest impact strength, while sample F (20% banana + 10% sponge gourd) has the lowest impact strength. It is evident that increasing the percentage of banana generally results in higher impact strength values. Sample B (10% banana + 5% sponge gourd) has higher impact strength than sample a (5% banana + 5% sponge gourd). The presence of sponge gourd in the composite can also influence impact strength. For example, sample G (5% banana + 20% sponge gourd) has a lower impact strength compared to sample C (20% banana + 5% sponge gourd), indicating that the combination of banana and sponge gourd affects the material's impact resistance.

The impact strength values at 300 µm fibre size also vary with different sample compositions. Sample E (10% banana + 10% sponge gourd) has the highest impact strength, while sample A (5% banana + 5% sponge gourd) exhibits the lowest impact strength. Increasing the percentage of banana tends to result in higher impact strength values. Sample B (10% banana + 5% sponge gourd) has higher impact strength than sample a (5% banana + 5% sponge gourd). The presence of sponge gourd still has an impact, with samples containing sponge gourd generally showing different impact resistance values. For instance, sample H (10% banana + 20% sponge gourd) has a lower impact strength (27.46) compared to sample E (10% banana + 10% sponge gourd).

At 600 µm fiber size, the impact strength values exhibit trends similar to those at 150 µm and 300 µm. Sample A (5% banana + 5% sponge gourd) has the highest impact strength, while sample G (5% banana + 20% sponge gourd) exhibits the lowest impact strength. Consistently, increasing the percentage of banana tends to result in higher impact strength values. Sample E (10% banana + 10% sponge gourd) has higher impact strength than sample D (5% banana + 10% sponge gourd). The presence of sponge gourd continues to influence impact strength, with samples containing sponge gourd generally showing different impact resistance values. Therefore, the impact strength of developed composites is influenced by the percentage of banana and sponge gourd as well as the fibre size. These trends are consistent across different fibre sizes, but the specific values vary depending on the sample composition. These observations collaborated with the report of Ekwedigwe et al., 2023 [6] on the improvement of the properties of polymer composite with natural reinforcements.

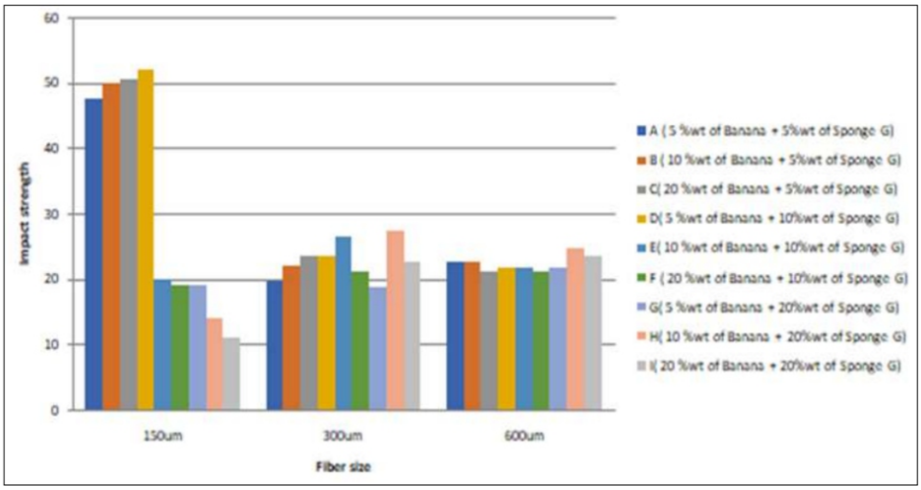

Fig 1: Impact strength properties of banana and sponge gourd particulates reinforced hybrid composite at different fibre size.

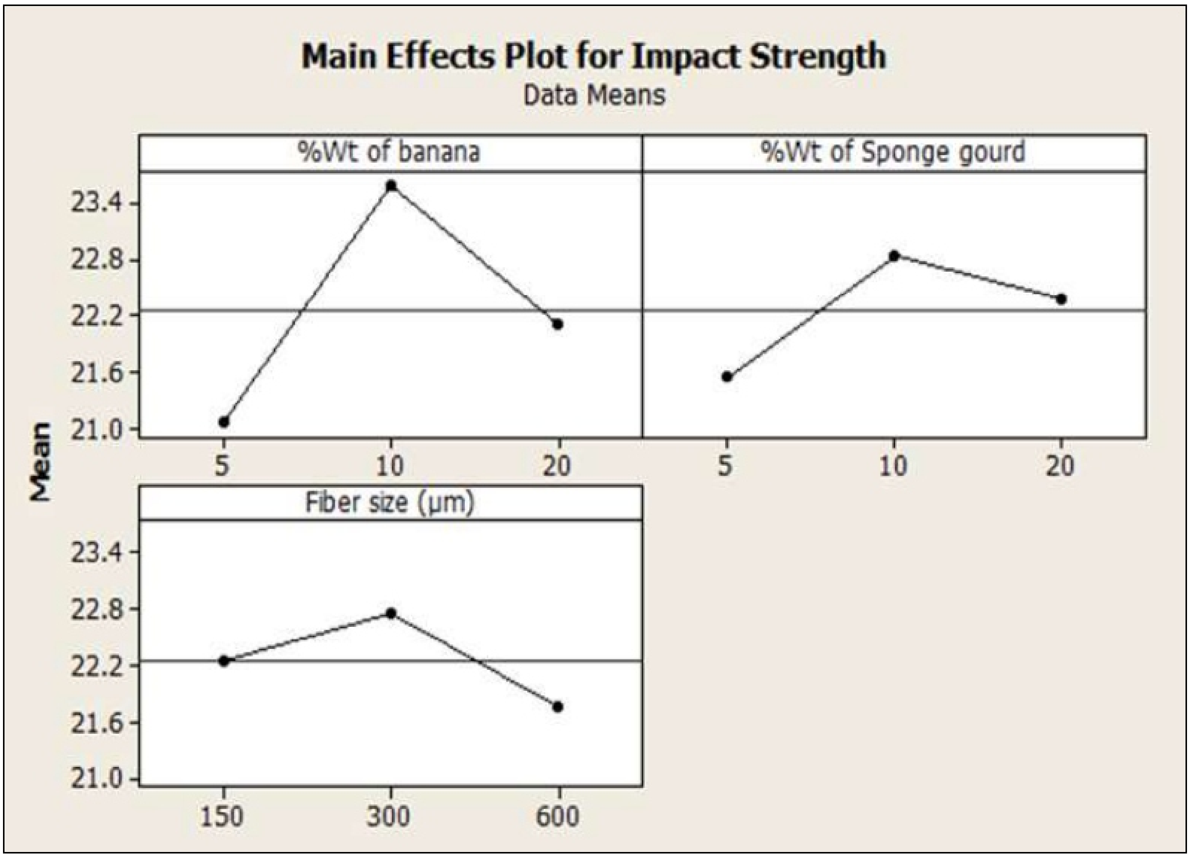

Fig 2: Main effect plot of impact strength versus the process parameters

Hardness Strength

Figure 3 depicts the hardness strength of the fabricated composite samples (A to I) at each fibre size. At 150 μm fibre size, the trend suggests that increasing the percentage of both banana and sponge gourd generally results in lower hardness. Sample C (20% banana + 5% sponge gourd) exhibits the lowest hardness at this fibre size. Sample B (10% banana + 5% sponge gourd) achieves the highest hardness at 150 µm among all samples, suggesting an optimal balance between the two components for hardness at this fiber size. On the lower end of the spectrum, sample I (20% banana + 20% sponge gourd) has the lowest hardness, showing that an excessive amount of both banana and sponge gourd can reduce hardness considerably.

The hardness at 300 µm fiber size varies significantly with different sample compositions. Sample G (5% banana + 20% sponge gourd) has the highest hardness, while sample C (20% banana + 5% sponge gourd) has the lowest. Sample F (20% banana + 10% sponge gourd) exhibits relatively high hardness, suggesting that a moderate increase in banana percentage can improve hardness at this fiber size. Sample I (20% banana + 20% sponge gourd) continue to have the lowest hardness at 300 µm, confirming that excessive quantities of both components can lead to lower hardness as reported by Ezenwa et al., (2020) [20]. At this 600 µm fibre size, the trend reverses, with higher percentages of banana generally resulting in higher hardness. Sample I (20% banana + 20% sponge gourd) achieve the highest hardness at this fibre size. Sample G (5% banana + 20% sponge gourd) also exhibits high hardness, suggesting that, at this fibre size, the presence of sponge gourd can contribute positively to hardness. Sample F (20% banana + 10% sponge gourd) has the lowest hardness at 600 µm, emphasizing that the optimal composition for hardness may vary with fiber size.Therefore, it can be establish that the effect of sample compositions on hardness varies with fibre size. There seems to be an optimal composition for achieving the highest hardness at each fiber size. Smaller fibre sizes tend to benefit from balanced compositions, while larger fibre sizes favor higher banana percentages. Additionally, excessive quantities of both components can lead to reduced hardness in most cases.

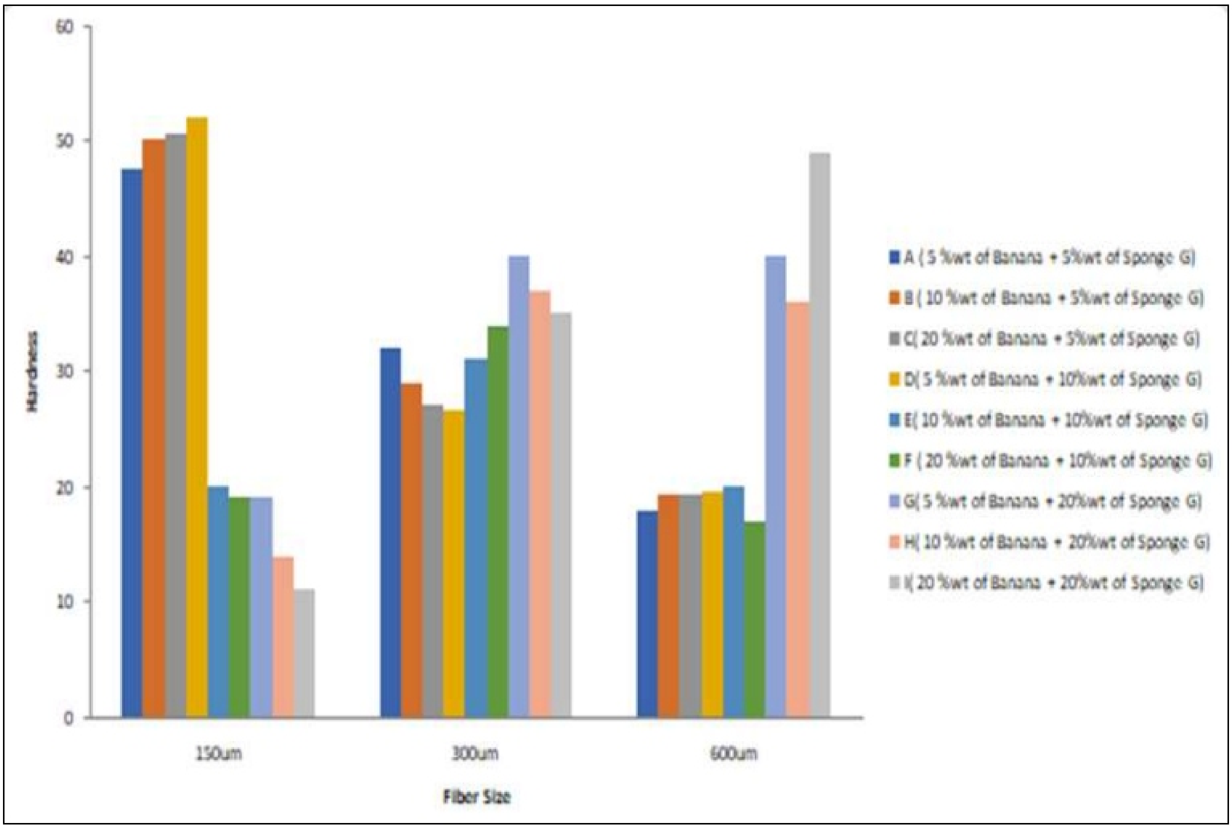

Fig 3: Hardness properties of banana and sponge gourd particulates reinforced hybrid composite at different fiber size

The main effects plot shown in Fig.4, presents the influence of the process parameters such as %wt of Ba, %wt of Sg fibre, and fibre size on the hardness of the hybrid polymer matrix composites.

The percentage of banana and sponge gourd in the composite materials has a significant impact on hardness. As the percentage of banana increases, the hardness generally increases, which is consistent with the reinforcing effect of banana fibers. For instance, when the % weight of banana is kept constant at 5%, an increase in the % weight of sponge gourd from 5% to 20% leads to a substantial increase in hardness. This is because sponge gourd, being a softer material, can benefit from the reinforcing effect of banana fibres. However, at higher levels of banana (10% and 20%), the increase in sponge gourd percentage does not result in a proportional increase in hardness. In fact, the hardness tends to plateau or decrease slightly. This suggests that there may be an optimal balance between banana and sponge gourd percentages that maximizes hardness.

The size of the fibres used in the composite materials also plays a crucial role in determining hardness. Smaller fibre sizes generally lead to higher hardness according to Atuanya et al., (2016) [21]. For example, when comparing samples with the same % weight of banana and sponge gourd (e.g., 5% banana, 5% sponge gourd), a decrease in fibre size from 600µm to 150µm results in a substantial increase in hardness. This trend is consistent across all compositions. For instance, at 10% banana and

10% sponge gourd, decreasing fibre size from 600µm to 150µm increases hardness significantly. Similarly, the interaction between the percentage of banana, sponge gourd, and fibre size is complex. While higher banana percentages generally lead to increased hardness, this effect can be modulated by the presence of sponge gourd and the fibre size. For instance, at 10% banana and 10% sponge gourd, increasing the fibre size from 150µm to 600µm results in a decrease in hardness. This suggests that the reinforcing effect of banana fibres is more pronounced at smaller fibre sizes and may be attenuated by the presence of sponge gourd. In addition, at 20% banana and 20% sponge gourd, the highest hardness is observed at a fibre size of 600µm, indicating that there may be an optimal combination of composition and fibre size to achieve the desired hardness as reported by Ekwedigwe et al., (2023) [6] and Atuanya et al., (2016) [21].

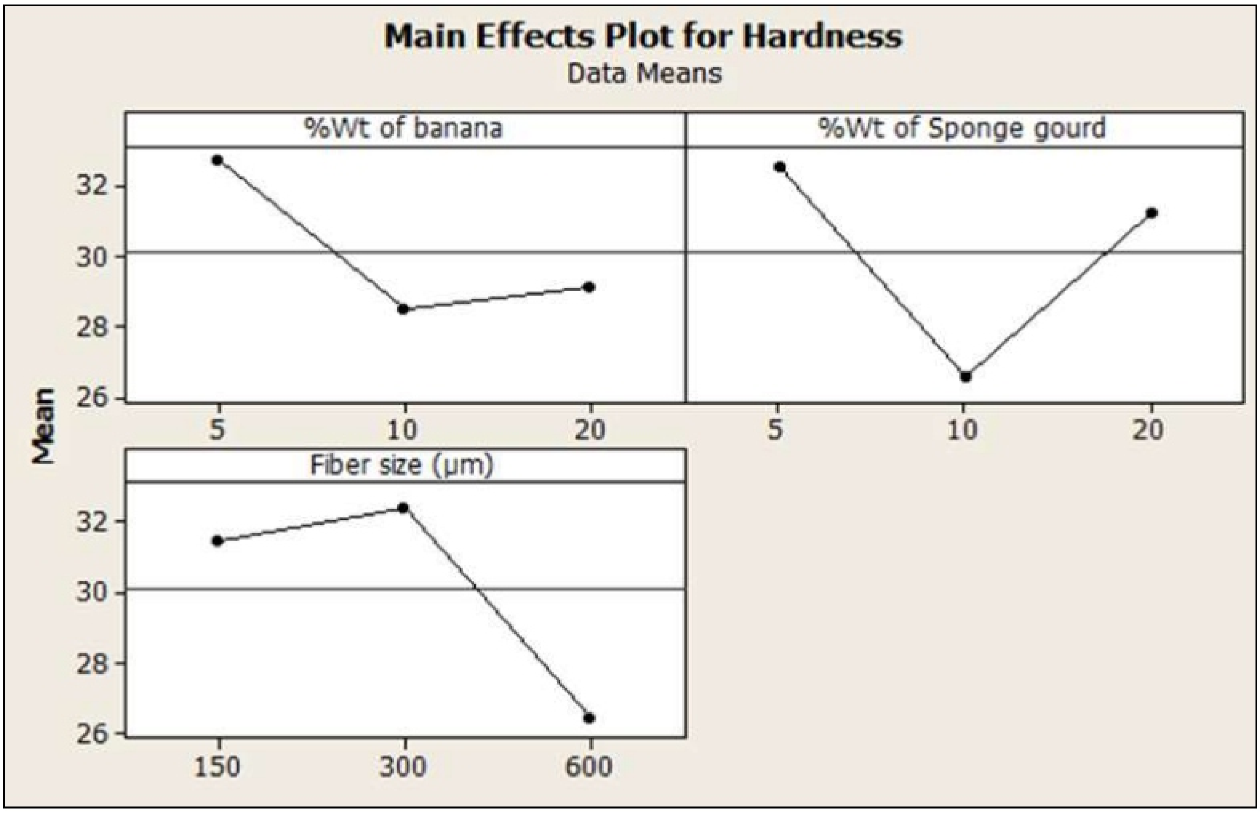

Fig 4: Main effect plot of hardness versus the process parameter

Conclusion

In this experimental study, the effects of banana fibre and sponge gourd fibre concentrations on the hardness, impact strength of Banana Fibre (BF) and Sponge Gourd Fibre (SG) hybrid composite for hockey stick application were explored in detail. The effects of hybrid concentrations on the tested properties were also investigated. The results of the study indicated that the developed natural fibre reinforced hybrid polymer composite recorded excellent hardness and impact strength behaviors at different concentrations of the reinforcements. The results of the study can be summarized thus: The best combination that gave the best hardness result were 5%wt BF + 5%wt SGF at 300µm fibre size, which also was within the range of values for hardness a material must possess before being considered for Hockey stick equipment, as the %wt of banana fibre and sponge gourd fibre increases, hardness of the hybrid materials reduces. The impact strength increases with increase in % wt of banana fibre and sponge gourd fibre, but reduces at 20% wt banana fibre and sponge gourd fibre. The optimum factors which gave the best impact strength were 10% wt BF + 10%wt SGF at 300µm fiber size which fall within the limit for impact strength required by a material before it can be utilized for the manufacture of Hockey stick. The study has established the optimum contribution of banana, sponge gourd fibre at specific fibre size that will produce a hybrid composite of better hardness and impact strength. The study also established the fact that the natural fibre-based hybrid composite can also be considered as material for Hockey stick fabrication.

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Advancement in flexible pavement with polymer

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A B S T R A C T

Polymer waste, also known as plastic waste, has become a significant environmental issue in recent years. The increased production and consumption of plastics have outpaced our capacity to manage and recycle them effectively, leading to a global crisis that demands immediate action. Polymer modified asphalt (PMA) has been increasingly used in flexible pavements due to its enhanced properties compared to traditional asphalt. Polymers increase the elasticity and flexibility of the pavement, allowing it to better withstand heavy traffic loads and temperature fluctuations. By using PMA, the life cycle of the pavement is extended, reducing the need for frequent resurfacing and reconstruction. PMB is a mixture of bitumen and polymers that improve its elasticity, adhesion, and durability. The higher the Marshall Stability value, the stronger and more durable the road will be. PMB is increasingly being used in road construction projects to improve the longevity and performance of roads.

Keywords: Polymer modified bitumen, Marshall stability

Introduction

CRMB, NRMB, SBS, EVA, and bitumen are all materials commonly used in road construction. CRMB stands for Crumb Rubber Modified Bitumen, which is a type of bitumen modified with crumb rubber to improve its performance and durability. NRMB, on the other hand, stands for Natural Rubber Modified Bitumen, which is another type of modified bitumen made from natural rubber. SBS and EVA are both polymer-modified bitumen, with SBS referring to Styrene-Butadiene-Styrene and EVA referring to EthyleneVinyl Acetate. This modified bitumen offers better adhesion, flexibility, and resistance to cracking compared to conventional bitumen, making them popular choices for road construction.

When modified bitumen are mixed with aggregates, they form asphalt concrete, which is commonly used as the top layer of roads. Bitumen, which is a sticky, black, and highly viscous liquid, serves as the binding agent that holds the aggregates together. This mixture is then laid and compacted to create a smooth, durable, and long-lasting surface for vehicles to travel on. Roads constructed using these materials are able to withstand heavy traffic, harsh weather conditions, and daily wear and tear, ensuring safe and efficient transportation for people and goods. With advancements in technology and materials, the construction of roads has become more sophisticated and sustainable, leading to the development of high-quality transportation networks that benefit society as a whole. Bitumen is a common binder used in road construction and maintenance. Virgin bitumen is the basic form of bitumen derived from the refining of petroleum. It is widely used as a binder in asphalt mixtures due to its ability to provide good waterproofing and flexible properties. However, virgin bitumen alone may not provide sufficient durability and resistance to deformation under heavy traffic loads. This has led to the development of polymer modified bitumen (PMB), which is produced by blending virgin bitumen with polymer additives. PMB offers improved performance in terms of fatigue resistance, rutting resistance, and overall durability, making it a preferred choice for high-traffic roads and highways.

Another type of bitumen commonly used in road construction is stone mastic asphalt (SMA), which is a mixture of coarse aggregate, fine aggregate, filler, and a high content of virgin bitumen. SMA offers excellent resistance to rutting and fatigue, making it suitable for heavy traffic conditions. Dense bitumen macadam (DBM) is another type of bitumen mixture that consists of crushed rock or gravel bound together with bitumen. It is commonly used as a base or binder course in road construction to provide structural support and resistance to deformation. Overall, the use of different types of bitumen such as virgin bitumen, polymer modified bitumen, SDBM, and DBM plays a crucial role in ensuring the durability, safety,and efficiency of road infrastructure.

Objective

The objective of of the study of using PMB in road construction is to improve the properties of the bitumen, making it more resistant to deformation, cracking, and aging. By adding polymers to bitumen, the resulting PMB has enhanced elasticity, durability, and resistance to high and low temperatures. These improvements lead to a longer service life of the road, reducing maintenance costs and increasing the safety and efficiency of the transportation system.

The stability of roads is a crucial factor in ensuring the safety and longevity of transportation infrastructure. PMB plays a significant role in improving the stability of roads by providing enhanced resistance to rutting, cracking, and fatigue. The increased elasticity of PMB helps to distribute the loading stresses more effectively, reducing the risk of deformations and failures.

Methodology and Design

The incorporation of polymer into bitumen improves its properties, making it more elastic and durable, especially under high traffic and varying weather conditions. PMB can provide significant benefits in terms of longer pavement life, reduced maintenance costs, and improved skid resistance. The methodology for producing PMB may vary depending on the specific requirements of the project, such as the type and amount of polymer used, blending techniques, and quality control measures. Overall, the use of polymer modified bitumen represents an innovative approach to enhancing the performance and longevity of asphalt pavements, ultimately contributing to safer and more sustainable road infrastructure.

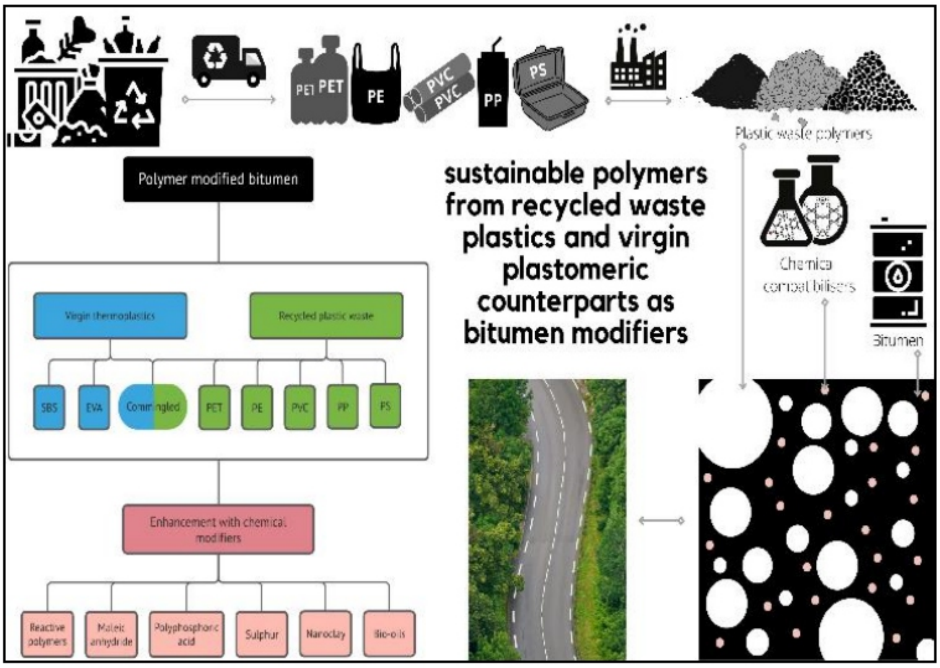

Fig 1: Polymer Modified Bitumen

When a polymer is added to regular bitumen, it becomes more elastomeric, which provides it with additional elasticity. The polymer that is added is styrene butadiene styrene (SBS), which acts as a binder modification agent. The primary objective of SBS polymer modified bitumen is to provide extra life to pavement, roads and construction designs. Some of the qualities exhibited by PMB are:

Higher rigidity.

Increased resistance to deformation.

Increased resistance to cracks and stripping.

Better water resistance properties.

High durability.

Advantage of using polymer modified bitumen

Stronger road with increased Marshall Stability value and greater Rigidity.

Better resistant towards rainwater and water stagnation.

No stripping and no potholes.

Better resistance to permanent deformation.

Reduction in pores in aggregate and hence less rutting and ravelling.

Much higher durability

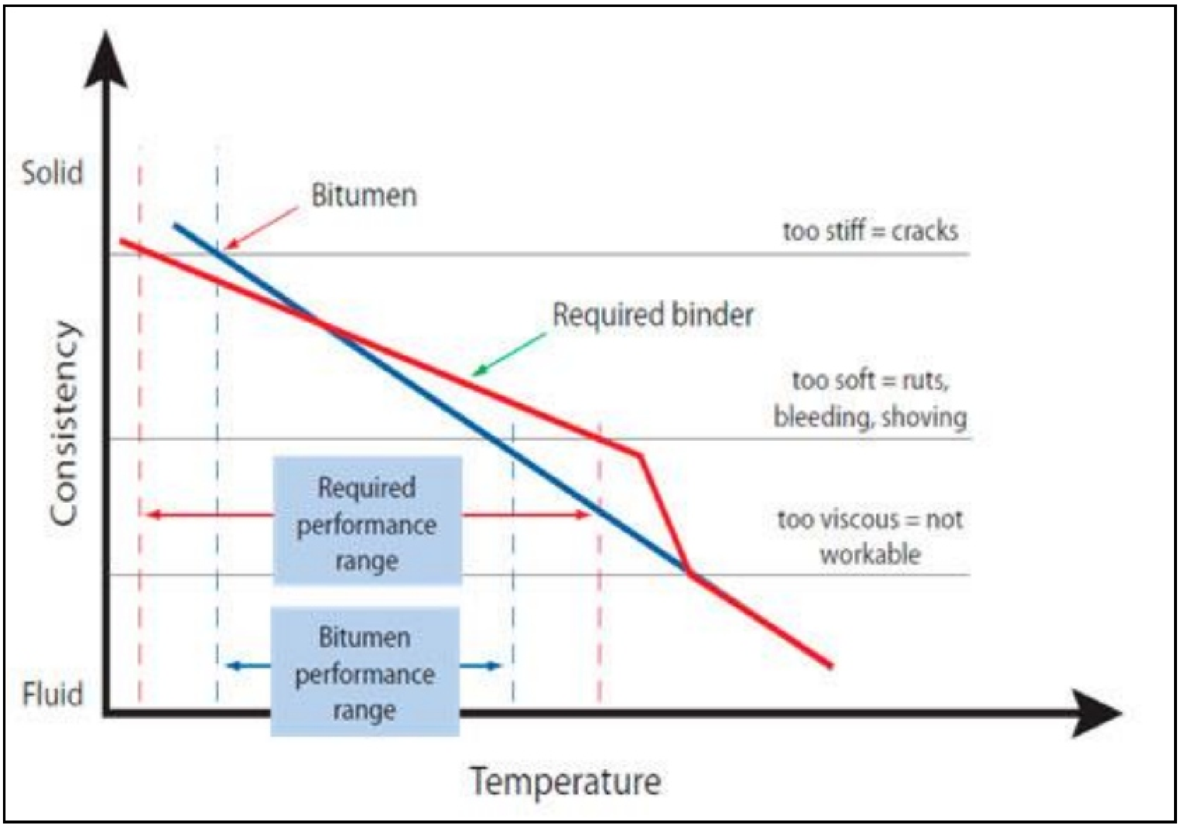

Fig 2: Consistency and temperature variation of PMB

Types of polymer modified bitumen

Table 1: Types of polymer in bitumen

Type	Generic Examples
Filler	Mineral filler
Extender	Sulfur
Plastic	Polyethylene/polypropylene
	Ethylene acrylate copolymer
	Ethyl-vinyl-acetate (EVA)
	Polyvinyl chloride (PVC)
	Ethylene propylene or EPDM
	Polyolefin
Rubber-Plastic Combinations	Blends of rubber and plastic
Fiber	Natural:
	Asbestos
	Rock wool
	Manufactured:
	Polypropylene
	Polyester
	Fiberglass
	Mineral
	Cellulose

Conclusion

In conclusion, polymer-modified bitumen is an innovative material that has shown great promise in improving the strength and stability of asphalt pavements. By incorporating polymers into the bitumen mixture, the resulting material is able to resist deformation and cracking caused by traffic loads and environmental factors. This enhanced durability ultimately leads to longer-lasting pavements with reduced maintenance costs over time.

The increased strength and stability provided by polymermodified bitumen also offer benefits beyond just pavement performance. Infrastructure such as roads and highways play a vital role in economic development and societal well being, and by utilizing advanced materials like polymermodified bitumen, we can ensure that our roadways continue to provide safe and reliable transportation for years to come. As research and development in this field continue to advance, the potential for even further improvements in pavement performance is immense, highlighting the importance of continued investment in materials science and engineering.

Acknowledgment

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Water proofing system in concrete structures

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A B S T R A C T

Water proof structure is a design concept that aims to repel water and prevent any moisture from seeping into the materials used in construction. This type of structure is particularly important in areas prone to heavy rainfall or flooding, as it helps maintain the integrity and durability of the building. Water proof concrete is formulated with additives and admixtures that create a barrier against water infiltration, making it ideal for areas prone to high levels of humidity or moisture. By incorporating this technology into construction projects, builders can ensure that their structures remain protected from the damaging effects of moisture, such as mold growth, deterioration of building materials, and potential structural issues. The use of abstract damp proof concrete represents a forward-thinking approach to building design and can greatly enhance the durability and longevity of a building.Crystalline admix water proofing with water stops, water proofing with Atactic Polypropylenemembrane, and injection are the water proofing systems most commonly used in basements. Using non-shrinking cementitious grout for waterproofing, concrete must have crystalline admixtures made of cementitious powder and water. For toilets in non-sunken places, water proofing with an elastomeric cementitious coating is used. In sunken areas, brick jelly cement concrete with inherent water proofing compound is used. In this paper it deals with the different types of water proofing system.

Keywords: Water proof concrete, water repellency, moisture prevention

Introduction

Waterproofing is an essential element in preserving the integrity of concrete structures. Concrete is a porous material that is susceptible to damage from water infiltration, which can lead to deterioration and structural issues over time. By applying a waterproofing membrane to the surface of the concrete, moisture is prevented from seeping into the material and causing damage. Waterproofing also helps to extend the lifespan of the concrete structure, saving time and money on costly repairs in the long run.

In addition to protecting the concrete itself, waterproofing also helps to protect any embedded steel reinforcement within the structure. Steel reinforcement is commonly used in concrete construction to provide added strength and stability, but it is vulnerable to corrosion if exposed to moisture. By waterproofing the concrete, the likelihood of corrosion occurring is significantly reduced, ensuring the structural integrity of the building for years to come.

There are various methods of waterproofing concrete structures, including using liquidapplied membranes, sheet membranes, and integral waterproofing additives. Each method has its own advantages and limitations, depending on the specific needs of the project. Properly waterproofing a concrete structure requires careful planning and consideration of factors such as climate, water exposure, and the intended use of the building. By incorporating waterproofing into the construction process, engineers and contractors can ensure that the concrete structure remains durable, safe, and aesthetically pleasing for many years.

Damp proof concrete is a type of concrete that is specifically designed to prevent moisture from seeping through its surface. This type of concrete is commonly used in areas that are prone to high levels of humidity or moisture, such as basements or crawl spaces. Damp proof concrete is typically made with additives such as waterproofing agents or special admixtures that help to create a barrier against moisture penetration. Additionally, the surface of damp proof concrete is often sealed with a waterproof coating to further enhance its resistance to water infiltration.

One of the key benefits of damp proof concrete is its ability to prevent water damage and mold growth in buildings. By effectively blocking moisture from entering the concrete, damp proof concrete helps to maintain the structural integrity of a building and prolong its lifespan.

Furthermore, damp proof concrete can also help to improve indoor air quality by reducing the risk of mould spores and other allergens from thriving in damp environments. Overall, damp proof concrete is an essential building material that not only enhances the longevity of structures but also contributes to a healthier and more comfortable living environment.

In general, water permeability of exposed concrete structures such as pavement and bridge deck affect the durability and corrosion of the reinforcing steel in the structure. Water-related problems such as freezing and thawing also cause serious degradation in reinforced concrete. Permeability is known to be influenced by the quantity, kind, and spread of the pores present in a substrate.

Therefore, infrastructures need to be inspected and maintained over time

Waterproofing is an essential aspect of building construction and maintenance. It helps to prevent water damage and deterioration caused by moisture, which can lead to costly repairs and even structural failure over time. There are several types of waterproofing methods and materials available, including membranes, coatings, sealants, and drainage systems. Membrane waterproofing involves the application of a thin layer of material, such as a sheet or liquid that forms a barrier against water penetration. Membranes can be made from a variety of materials, such as rubber, bitumen, Polyvinyl chloride or polyurethane. They are often used in areas that are prone to moisture, such as roofs, basements, and foundations. Coating waterproofing involves applying a protective layer of material, such as a paint or sealant, to the surface of a structure to prevent water penetration. Coatings can be applied to a variety of surfaces, such as concrete, masonry, and metal. Sealant waterproofing involves filling gaps and joints with a water-resistant material, such as silicone or polyurethane, to prevent water from entering the structure. Sealants are often used around windows, doors, and other areas where there may be gaps or joints. Drainage systems are designed to remove excess water from the building envelope and prevent water from accumulating around the foundation. They can include systems such as French drains, sump pumps, and gutters. Proper installation and maintenance of waterproofing systems is essential to their effectiveness. Regular inspections and repairs can help to prevent water damage and extend the life of the structure. It is also important to choose the appropriate waterproofing method and materials for the specific needs of the structure and its environment.

Objective

The broad objective of this study is as under

Waterproof concrete is to prevent water from infiltrating the structure and causing damage to the building. This is particularly important in areas that experience heavy rainfall or are prone to flooding, as water infiltration can weaken the structural integrity of the building and lead to costly repairs.

Waterproof concrete is to provide a durable and longlasting solution for structures that are exposed to harsh environmental conditions. By preventing water from entering the concrete, waterproofing helps to extend the lifespan of the building and reduce maintenance costs in the long run.

Methodology and Design

Waterproof concrete is a crucial technology in the construction industry, as it enhances the durability and longevity of concrete structures in various environmental conditions. The methodology behind waterproof concrete involves the incorporation of various admixtures and additives to improve the water resistance of the concrete mixture. Some of the common admixtures used in waterproof concrete include superplasticizers, fly ash, silica fume, and water repellents, which help reduce the permeability of the concrete and enhance its resistance to water penetration.

In addition to admixtures, the methodology of waterproof concrete also involves proper concrete mix design and construction practices. The proper selection of concrete mix proportions, curing methods, and construction techniques are essential to ensure the successful implementation of waterproof concrete. Proper compaction of the concrete mixture, adequate cover thickness, and effective joint sealing are also crucial factors in achieving a watertight concrete structure. Overall, the methodology of waterproof concrete requires a combination of proper materials selection, mix design, and construction practices to achieve a durable and waterproof concrete structure.

Table 1: Classification of agents based on the material

No.	Materials	Examples	Effect on Concrete
1.	Macro	Silanes, siloxanes	Showed to have the ability to resist water absorption by 98% and increase Static water contact angle to 164 in the treated sample
		Silicates containing compounds	Reduced water absorption up to 98.5% and showed the lowest chloride penetration depth of 1 mm compared to the control sample
2.	Micro	Polymers	Reduced water absorption up to 98.96% and decreased chloride penetration depth to 1 mm in the treated sample
3.	Nano	SiO_2, ZnO_2 and nano clay	Could reduce chloride penetration by 69% and increase static water contact angle to 142°

Surface Coating: Surface coatings are the waterproofing methods applied on the surface of substrates either by dipping, brushing and/ or spraying to serve as coatings. They are usually applied for repair or improvement of service life of an infrastructure. They can be polymers, silanes, and siloxane-based additives. Some additives have low water absorption and high -water vapor transmission.

Micro Materials: Micro materials are basically polymers as well as their dispersions and emulsions. Here, the reduction of water absorption was noticed to be up to 98.96%. Also, the maximum reduction of 94% reduction in chloride ingress was reported. In addition, long term durability of the substrate in the acidic environment was compromised.

Nano materials

Nano materials used here are nano-SiO2, ZnO2, and Nano clay. These Nano materials were incorporated to improve water repellence. Static water contact angles of 120°, 130°, and 142° were reported.

Conclusion

According to the studies analyzed in this paper, the following conclusions are drawn.

External coating and membrane are one of the common techniques of water proofing concrete structure.

Most of the researchers were used of surface coating.

Use of polymer-based materials, silicates containing compound, cementing materials and some of the Nano materials are the futuristic approach for this domain.

Internal mixing of hydrophobic material in concrete are proved more stable and provide better performance for water proofing structures.

Acknowledgment

I express my deep sense of gratitude to Deepak Kaushik, Assistant Professor, Department of Civil Engineering, Lingaya's Vidyapeeth Faridabad, Haryana for her invaluable help. I am highly thankful to her for continuous support and encouragement in completing this work.

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The use of GIS in the exploitation of rainwater running in the region from Fouka to Ras Alam alRum in the northwestern coast of Egypt

Ihab F Neamah

A B S T R A C T

The aim of the study is to employ geographic information systems in the exploitation of rainwater runoff in the region from Fouka to Ras Alam al-Rum in the northwestern coast of Egypt, where this region is characterized by highly variable precipitation, and the northwest coast depends entirely on rainwater for agriculture, drinking and domestic uses. Therefore, rainwater must be exploited during periods of rain interruption by selecting the optimal sites for its collection, depending on the geology of the region, the climatic and hydrological characteristics, the surface characteristics, and the topographical characteristics. We used the GIS program to analyze and process the data. It is located south of Ras El Hikma and includes part of the Fuka Basin, The study data spans the period 1990-2019.

Keywords: Rainfall, geographic information systems, surface runoff

Introduction

Water is the most important requirement for building and developing societies, Water is one of the most environmental elements that need management and construction [1]. So it is necessary to manage water resources, especially in arid and semi-arid regions that are affected by a lack of rainfall, As the appreciation and management of water resources gains a great place in the strategic planning of all peoples of the world [2, 3, 4] and one of the solutions to overcome this shortage is building dams and watersheds to collect rainwater [5]. Dams are among the largest water installations and have positive and negative effects. One of the positive effects is the provision of water needed for economic and social growth [6].

The selection of these catchment sites in dry areas is a complex process because these areas lack infrastructure and means of transportation, as the valleys of the region have large areas, and here comes the role of geographic information systems in studying water resources and how to exploit them and search for the best places to build The watersheds in the study area, which positively affects the population of the region socially and economically, The link between geographic information systems and spatial data analysis is an important matter in research and exploration [7, 8].

And the harvested rainwater can be used in all domestic and agricultural uses, Rainwater harvesting methods differ according to the prevailing climate and geographical location, where the best method must be chosen technically, economically and climatically for the region [9, 10, 11], as the northwestern coast region of Egypt depends on rainwater as a main source of drinking water for humans and animals and for agriculture, and the annual average rainfall is 140 mm, which makes this area one of the promising areas for harvesting rainwater, especially with the state's tendency to develop the northwest coast in light of the lack of groundwater and seawater leakage into some of its layers.

Study area

The study area extends between latitudes 30o55' and 31o23' north of the equator and longitudes 27o17' and 28o00' east of Greenwich meridian. Geologically, due to its recent formation, it is affected by marine influences coming from the Mediterranean Sea in the north, which helps in precipitation, which is the main source of surface runoff as it has aneffect on temperatures. Figure (1)

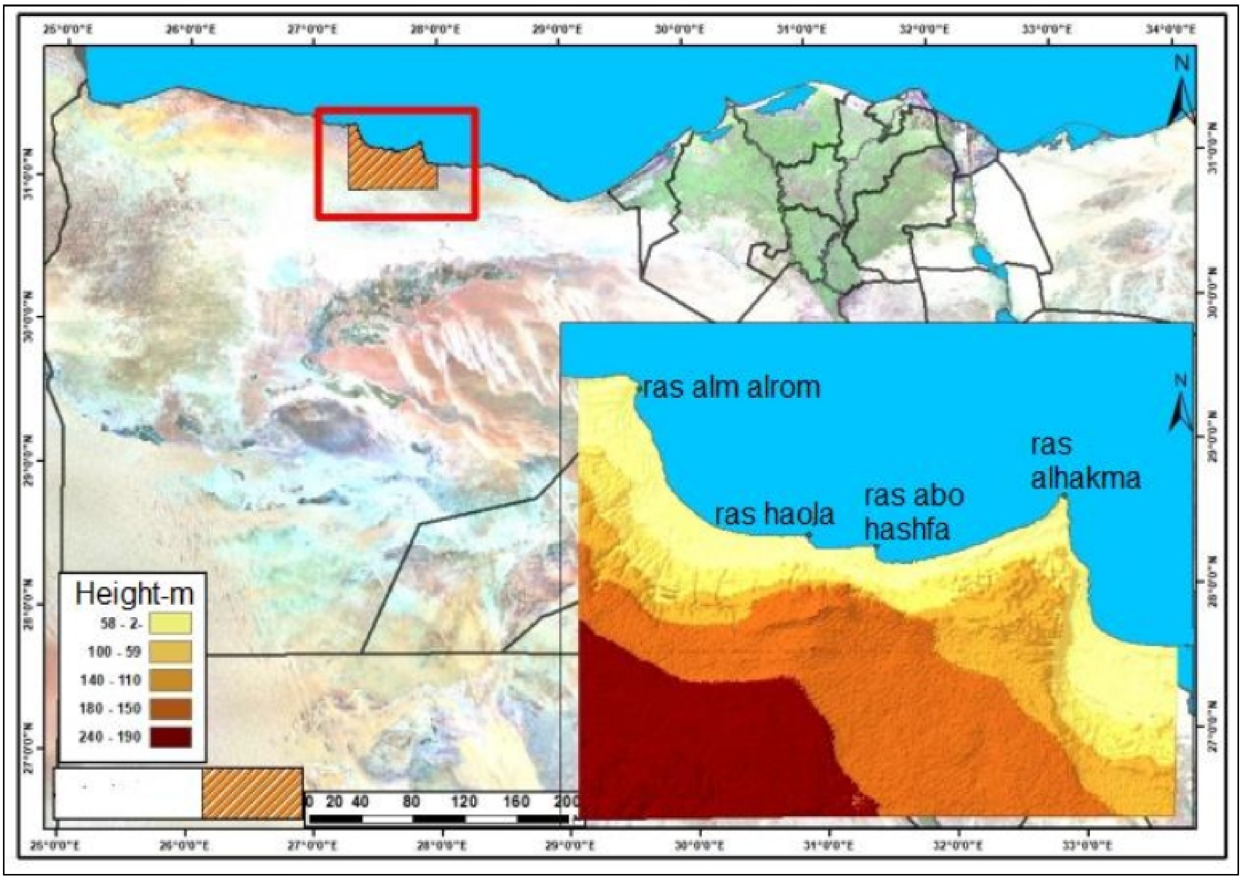

Fig 1: The location of the search area

The study Problem

The study area relies mainly on rain to meet domestic, agricultural and other needs, as the source of groundwater is unreliable due to the intrusion of sea water into the coastal aquifers, and the average annual rate of rainfall is 140 mm, so it is considered one of the areas suitable for water harvesting, especially with regularity. Rainfall in it and benefit from the harvested water in the field of agriculture and livestock breeding and for human use according to the implemented method of water harvesting, which contributes to the integrated management of water resources in this region.

The aim of the research

Choosing the optimal sites for collecting rainwater and using it to benefit from it later, based on the GIS program, to achieve water security for the residents of the region.

Study methodology

The study relied on the GIS program in conducting the necessary analytical operations and on the Google Earth pro program in drawing the necessary plans and satellite maps. The map return process, where the Global Mercator projection (UTM, WGS-84) was used, and these maps were digitized using GIS software. Spatial data was linked to Attribute data, and then the data was analyzed. Hydrological modeling was used and the Model Builder was used to determine the suitability of natural and human conditions. To choose the best sites for rainwater harvesting.

Criteria for determining optimal sites for water harvesting

1. Surface properties

The surface characteristics include the structure, geological composition, and degrees of slope, and they have a significant impact on the collection of rainwater. The area is characterized by its recent geological formations Figure (2). The geological map of the area. The terrain has a direct impact on surface runoff and rain harvesting. Figure (3) shows the digital elevation model of the study area.

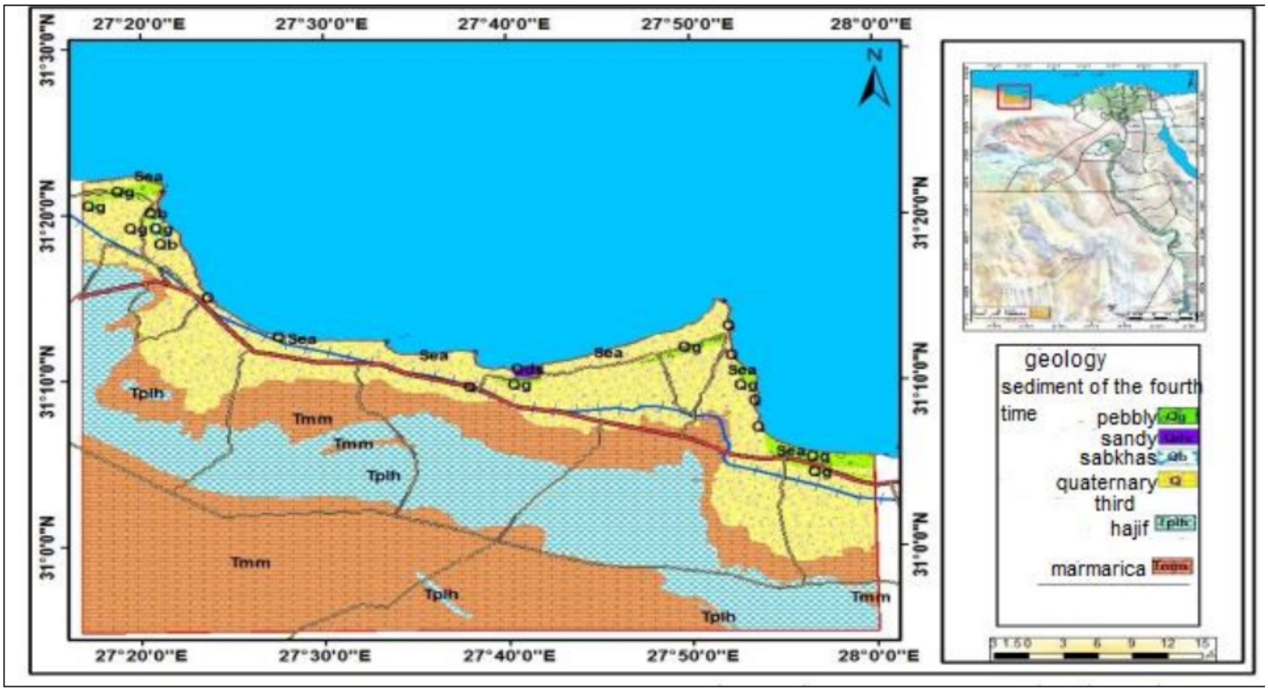

Fig 2: The geological map of the area

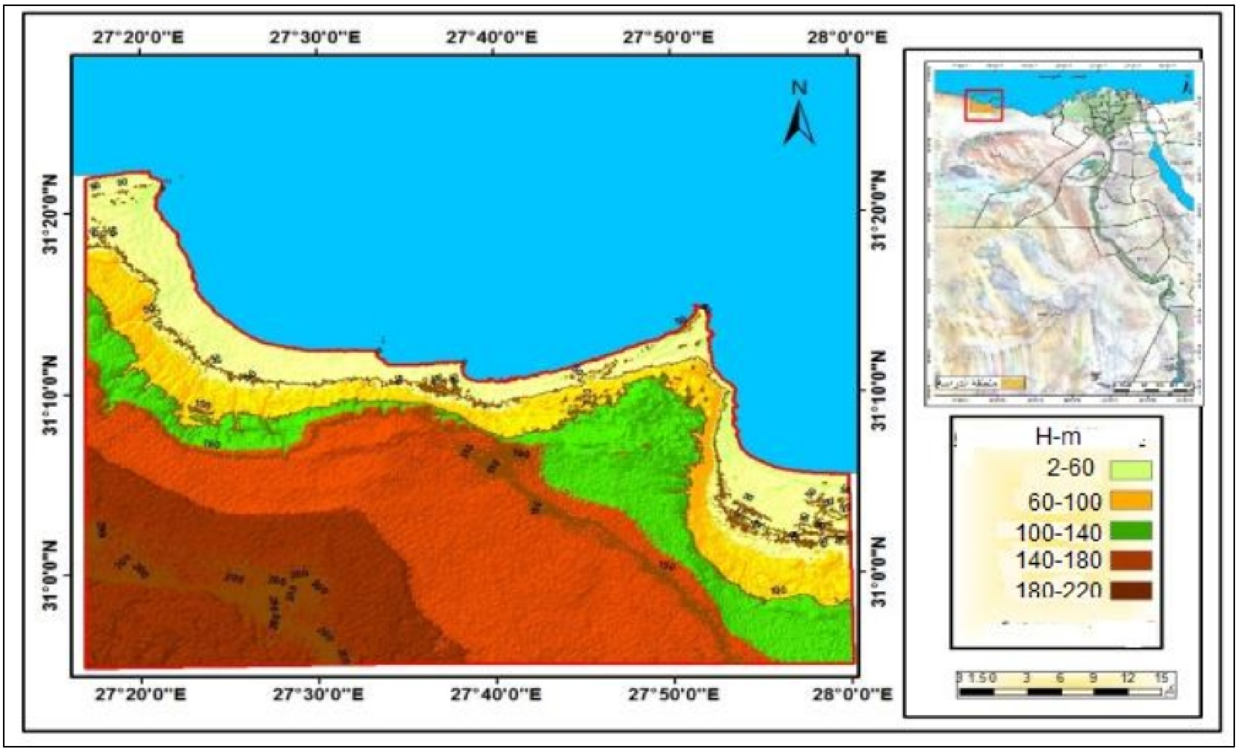

Fig 3: The digital elevation model of the study area

Degree of regression

The degree of slope has a major role in choosing water collection sites, as the degree of slope is directly proportional to the velocity of flow, Figure (4) shows the degree of slope in the study area, according to [12] division of the categories of slope, the area is dominated by light and medium slope, and the higher the speed Slope The flow velocity increases during rains, which leads to an increase in net runoff and groundwater recharge, which is located in the mouths of the valleys.

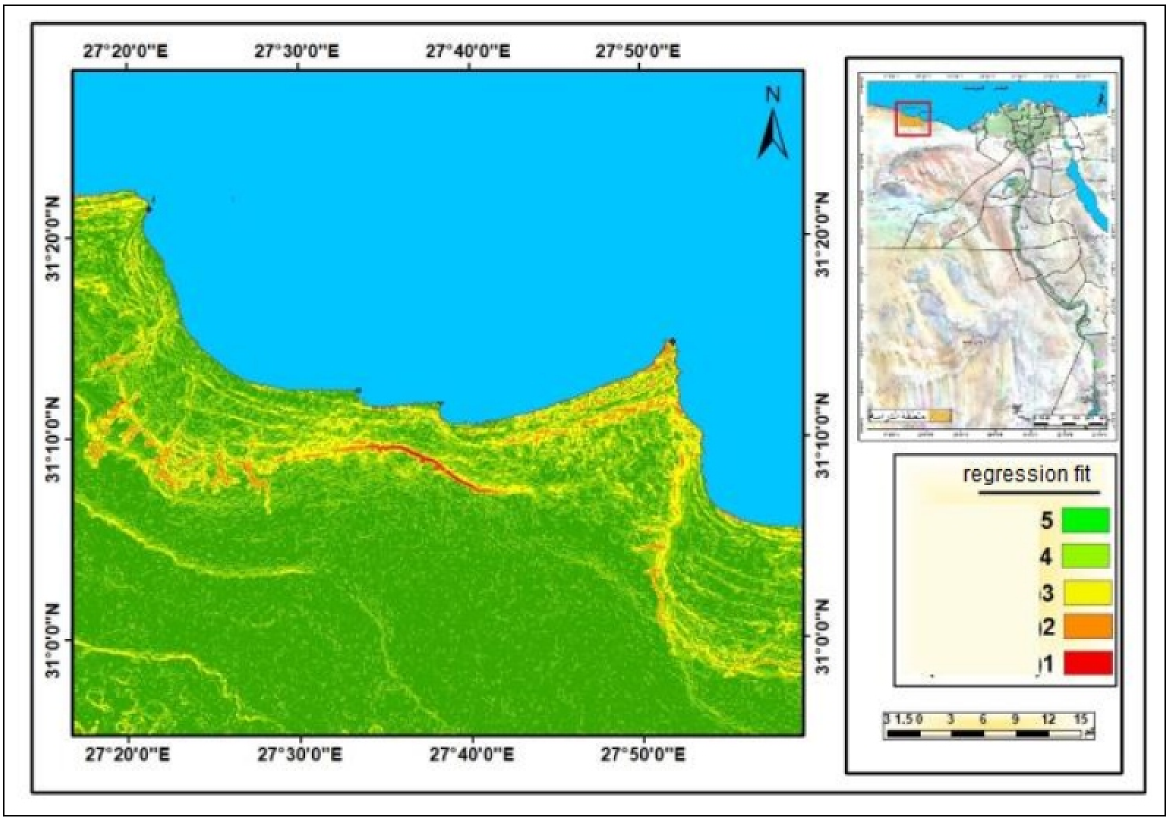

Fig 4: The degree of slope in the study area

Structure and geological structure

We need an area with a strong geological composition that does not allow landslides to construct wells and water collection reservoirs. Figure (5) shows the suitability of the study area for drilling wells and reservoirs according to the characteristics of the geological structure.

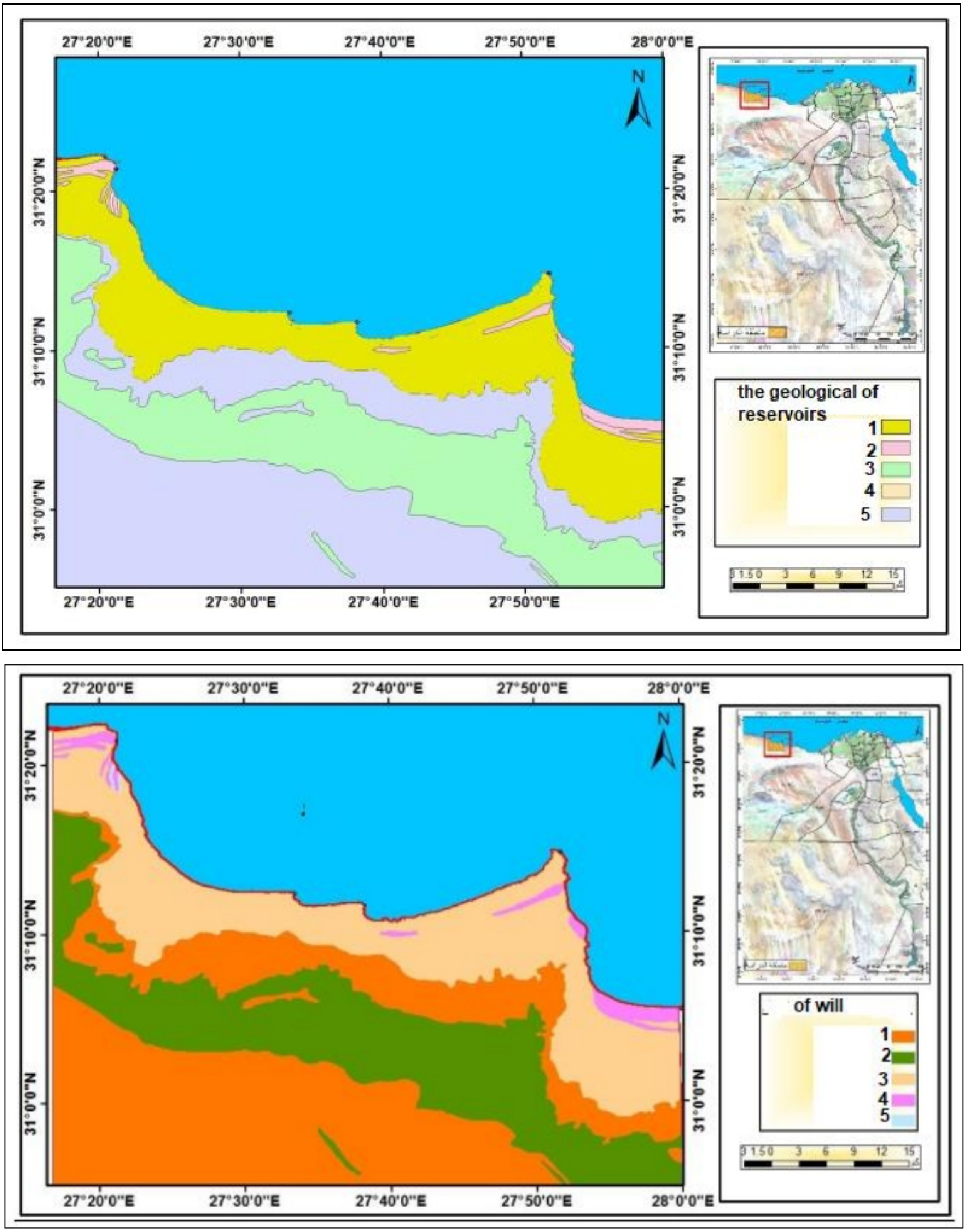

Fig 5: The suitability of the study area for drilling wells and reservoirs according to the characteristics of the geological structure

We notice from the previous figure that most of the study area is suitable for the construction of wells, especially the southern parts of it. The area of the first degree amounted to approximately 45% of the region's area, while the area of the second region amounted to 28.4%, and the third 25%, while the area of the fourth and fifth degrees together amounted to about 2% due to the smallness of these formations in the region.

1. Climatic variables

Rains

The amounts of rain in the northwest coast stations were as follows:

Table 1: The amounts of rain in the northwest coast stations

Station	Alexandria	Marsa Matrouh	Salloum	Siwa
Precipitation mm	192,8	153,2	115,8	5,1

Meteorological Authority data for the period 2000-2019

The amount of rain decreases from the north to the south, and the residents of the region depend on the rain as a result of its heavy fall on the northwestern coast in general.Figure (6) shows the evaluation of the area according to its suitability for constructing rainwater harvesting tanks.

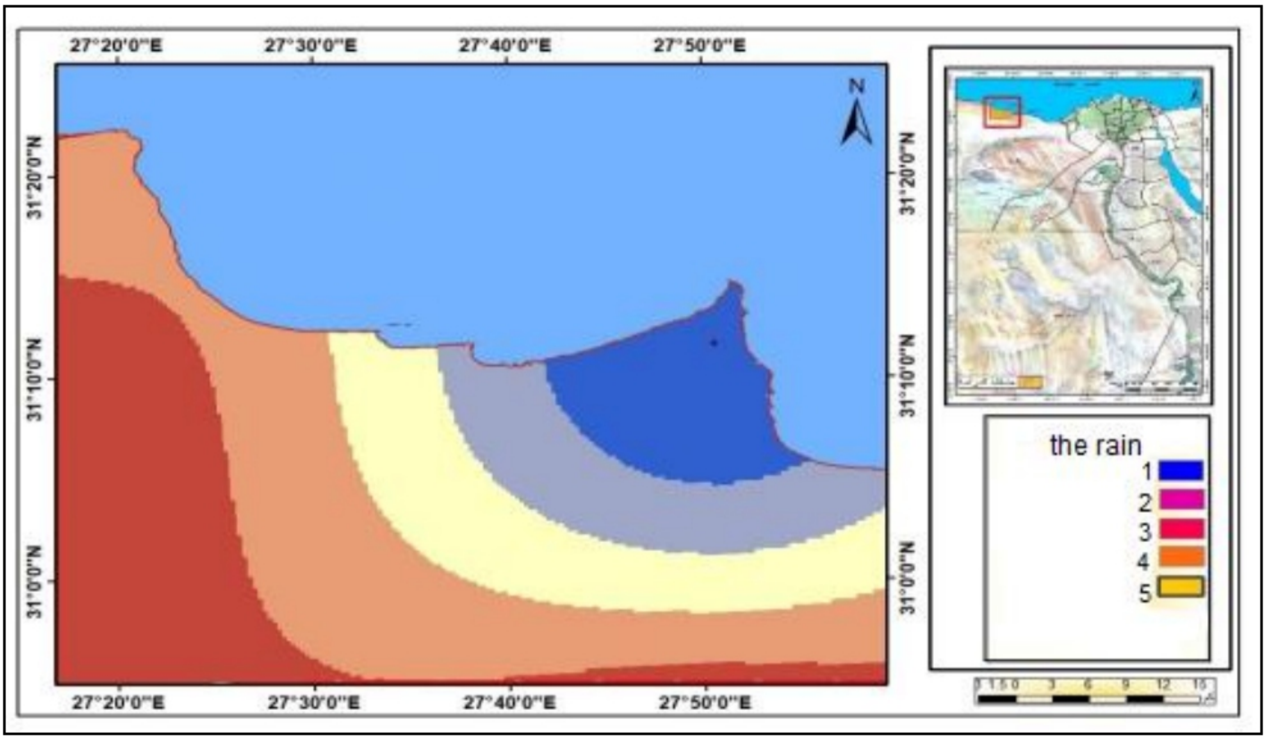

Fig 6: The evaluation of the area according to its suitability for constructing rainwater harvesting tanks

We note that the first degree of suitability is given to the areas in which the amount of rain exceeds 210 mm per year, which is in the Ras al-Hikma area. We note that the south of the study area is less suitable due to the low amount of rain.

Temperatures: Temperatures affect all climatic elements, as they affect the amount of water stored behind dams and affect the amount of evaporation, and greatly affect the selection of rainwater collection sites. Water depending on the temperature.

The following figure shows the region's assessment of its suitability for drilling wells and reservoirs according to the temperatures in the region in the period (1990-2019).

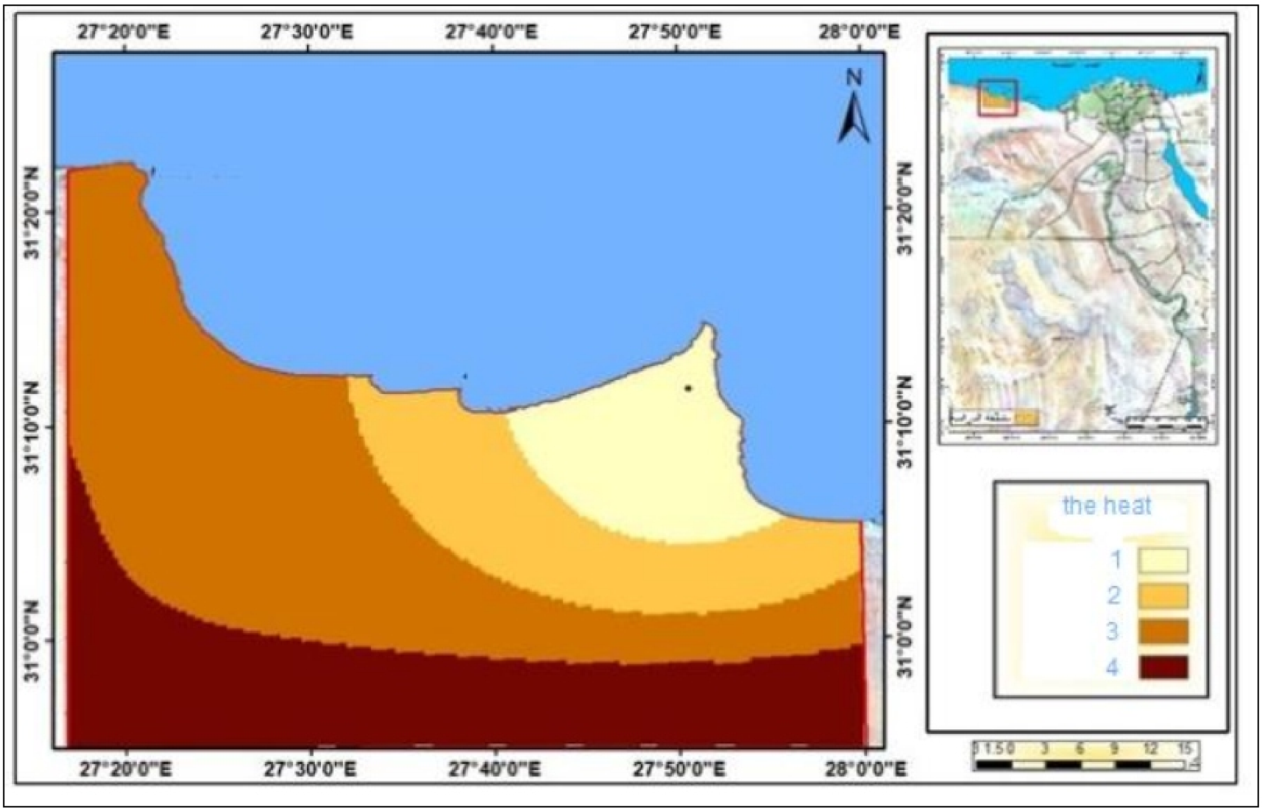

Fig 7: Evaluation of the area according to its suitability for constructing water collection tanks according to temperature.

Evaporation

Evaporation is a form of water loss, and it is considered one of the obstacles facing the construction of water collection reservoirs. Figure (8) shows the evaluation of the area according to its suitability for the construction of water collection reservoirs, depending on the amount of evaporation in the period 1990-2016.

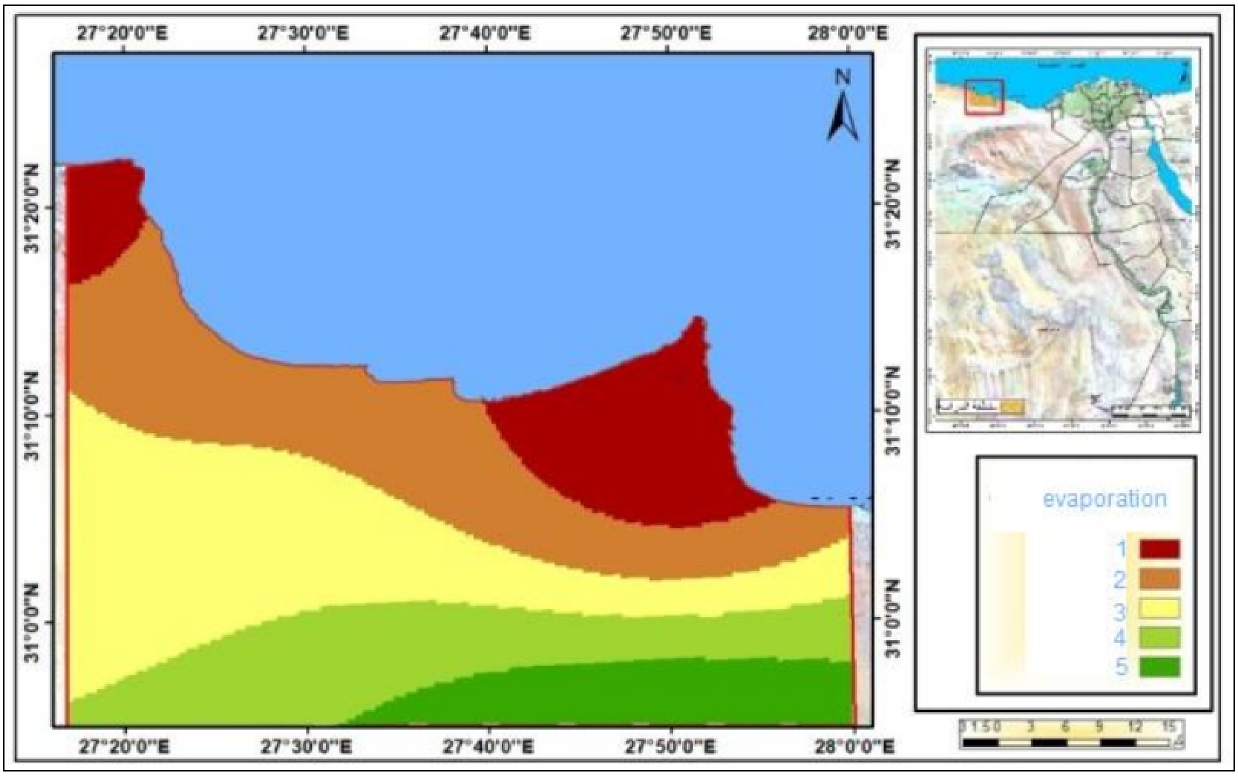

Fig 8: Shows the evaluation of the area according to its suitability for the construction of water collection reservoirs, depending on the amount of evaporation

The previous figure shows that more than a third of the region's area is in the first and second degree of suitability, and the northern parts of the region are the most suitable regions according to the amount of evaporation.

Soil properties

Soil properties affect rainwater runoff. Soils of low permeability reduce the amount of infiltrated water, i.e. their degree of suitability for constructing water collection tanks decreases. Figure (9) shows degrees of suitability for water collection according to soil permeability.

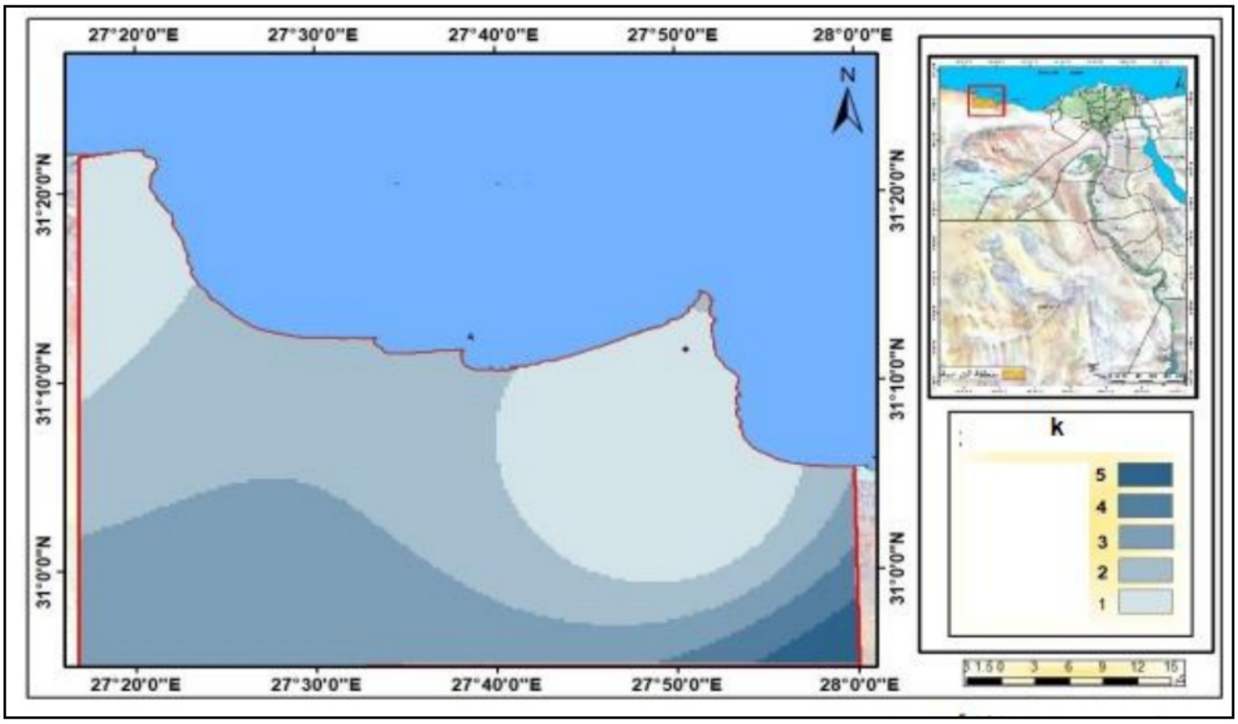

Fig 9: Degrees of suitability for water collection according to soil permeability

2. Hydrological variables

Hydrological variables are among the factors affecting the degree of suitability for constructing water collection tanks.

The most important of these variables are:

1. The amount of leakage during the discharge time.
2. The volume of surface runoff.
3. Net flow.

Applying the Model Builder model and obtaining the most suitable place to construct water collection tanks in the region.

We used Gis 10.3 to build the Model Builder as follows

1. We divided the region based on the criteria and classifications (Classification and Reclassification), where it was divided into 5 grades, and we gave grade 5 to the high-priority areas and grade 1 to the rejected areas.
2. Merge all layers into one layer.
3. Giving weight to each layer separately according to its importance.
4. Producing a new layer divided according to its degree of priority to the optimal sites.

5. Determine the areas that take grade 5 as ideal areas for water storage facilities.

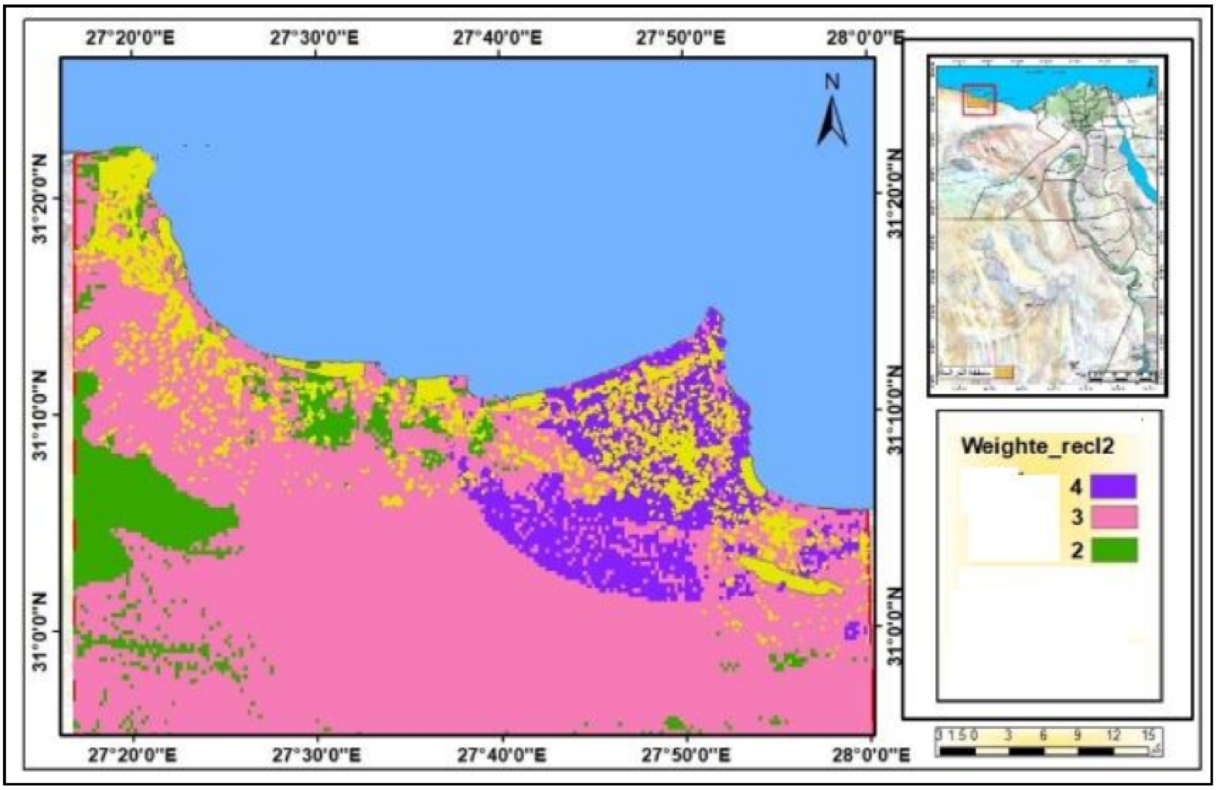

Fig 10: Classification of the study area according to its suitability for constructing water collection tanks according to the Model Builder

Results

Depending on Figure (10), we suggested the most suitable sites for collecting rainwater so that it is collected before it is lost by leakage and evaporation. By analyzing the previous data, we reached the following results:

The study area lacks the first degree of suitability, and the reason for this is that the area does not contain a place that meets all the conditions and criteria necessary for the construction of water collection tanks.

The area of the second degree was estimated at 310.48 km2, or 13.6% of the area of the region, which is the areas with heavy rains and little evaporation, which is the area south of Ras al-Hikma and parts of the Fouka Basin.

The area of the third degree was 145.18 km2and was represented in the southern parts of the region, which is characterized by the hardness of its rocks.

Based on the previous study and the spatial and geological analyzes of the study area, we proposed the construction of wells and reservoirs to collect rainwater within the second-class appropriate area that extends south of Ras al-Hikma and parts of the Fouka Basin, taking into account the residential communities and the various activities spread within this area.

As for the southern region of the study area, which is considered a third category because of its rock hardness, it can be relied upon to build water collection tanks only.

As for the fourth study areas, they are areas that extend away from the coast towards the southeast. In these areas, water collection tanks can be constructed, but in a small number due to the lack of appropriate conditions.

The study area is dominated by the third degree, and therefore the construction of collection tanks is the ideal solution for rainwater harvesting.

As for the prohibited areas, they included residential communities, agricultural lands, and areas near the coast, and this is what makes us rely on building reservoirs within the third area instead of digging wells within the second-class areas.

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