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The Impact of Construction Activities Near the Gulf: The Likelihood of Construction Materials Effect, ERA and Sustainable Development

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Abstracts: The environmental risks associated with construction activities are being monitored, especially given the global construction boom, in which the United Arab Emirates is a major participant. Construction activities near Gulf water cause variations in the ecosystem, yet whilst the Environmental Protection Agency (EPA) has given much attention to environmental risks resulting from construction material during construction activities to streams and rivers, there has been limited exploration of those risks in the Gulf. This research paper aims to identify the best practices in Environmental Risk Assessment (ERA) in order to contribute towards the achievement of sustainable development. Specifically, the objective is to determine the relationship between the parameters of water quality (turbidity and pH) that affect the ecosystem during construction activities in the hot summer and to frame effective ERA, to pursue this aim, 32 water samples were collected from the Gulf water in two locations; the first adjacent by 12 m to the Gulf and at a 500 m distance from the second, inactive location in Abu Dhabi city, UAE. All these water samples were taken during the peak time of construction activities, and after six hours of no activities, taking into consideration the weather conditions. Samples were tested in the environmental laboratory within 24 hours. The temperature is particularly considered to predict future levels of variation and consider risks that will affect such areas and seasons. The results indicate that a maximum turbidity level of 25.2 NTU (Nephelometric Turbidity Units) was noticed when the temperature was 43°C and pH 5.9 at the active construction. Hence a strong relationship between turbidity, pH, and temperature and their impacts on the water quality of the Gulf during construction activities is revealed. Outcomes are promising in effective risk management for sustainable development of the Gulf ecosystem during construction activities. The study demonstrates the need for a successful risk management framework to focus on the construction material management treatment that can decrease turbidity and adjust pH in the Gulf water near active construction. In addition, managing statistics of the communities residing near the Gulf and re-evaluating environmental risks are crucial.

Keywords: Construction Activities, Construction Material, Environmental Risk, Water Quality.

1. INTRODUCTION

Construction site activities are countless, ranging from excavation to structural framing and infrastructure development, and in combination they have an enormous effect on the environment. However, the environmental impact of construction has been given more attention [1] than the characteristics of construction materials and how these impact environmental functioning, and in exploring the former issue, it has been revealed [2] that the environmental impacts of such activities are not universal but rather vary from one country to another. Consequently, research in different parts of the world is necessary to build a comprehensive intelligence on this matter, and in this respect, Koleosho and Adeyinka [3] show the need for investigation of environmental changes caused by construction activities and their impacts on the water quality of the Gulf.

Reflection of goal no. 9 of the United Nations Sustainable Development Goals (SDGs) is crucial to improving construction materials management and identifying sustainability [4]. The Clean Water Act reports the quality of surface water to the EPA [5] every two years and this applies whatever the water's intended use - drinking, navigation, recreation, etc. This reporting frequency is necessary since turbidity discharge is much higher than would be observed naturally. More importantly, historic contaminations caused by pollutants run-off have been carried to water surfaces in a solution that is derived from construction materials and equipment on construction sites. This makes it important to secure more data on turbidity in order to verify the maximum allowed concentrations [6]. Simultaneously, weather conditions should be considered, for example, turbidity has been highly correlated with the quantity of wind received preceding [7] and has been seen to increase temperature dynamics [8].

Construction materials and their associated hazards are a main concern, requiring effective risk mitigation for sustainable development. For example, water surface pollution from floating slag and fly ash in cement has been experimentally identified as suspended solids [9], and when the temperature increases, fly ash becomes dry and airborne. One study has identified the relationship between turbidity and pH when the cement contains phosphorus, showing the dissolve rate from turbidity-related phosphorus increases for water if the potential of hydrogen is between 4 -7 pH [10].

However, it is not enough to identify relationships between the construction activities and the risks posed to the environment; in addition, the composition of construction materials and the associated risks must be observed. For example, fly ash, and slag as cementitious materials have a direct effect on the ecosystem, being transported by air or stormwater run-off, consequently contributing to the damage to the nearest water surfaces. And where a construction project has impacted the local environmental functioning through negative effects on the water quality, water currents, flow, and water temperature, then appropriate solutions should be provided by the project [11]. Water turbidity due to construction material sedimentation being carried into the water's surface [12] has recently been addressed by the EPA which has imposed a limit of 280NTUs of run-off from construction sites (20 acres - 81,000 sqm or more). In addition, pollutants like volatile organic compounds (VOCs), cement, paint, and glues including toxic chemicals transported from construction activities by air to run-off water surface are also considered [13]. Hence, this study is concerned with the risks of turbidity and pH inter-relationship associated with construction materials during construction activities in hot summer weather. However, effective turbidity removal could be achieved by macro (flocculation) and micro floc formation (coagulation) since the pH has been determined.

Authorities in the UAE have raised awareness of the inclusion of coastal construction developments within the notion of sustainable development for environmental safety, and therefore, the study is an important response to that focus. Its objectives are to: investigate the causes and effects of environmental impact coming from construction activities as reported in the literature; examine the effective risk assessment process for environmental functioning; and achieve a framework for best practices in construction activities to achieve Sustainable Development Goal No. 9.

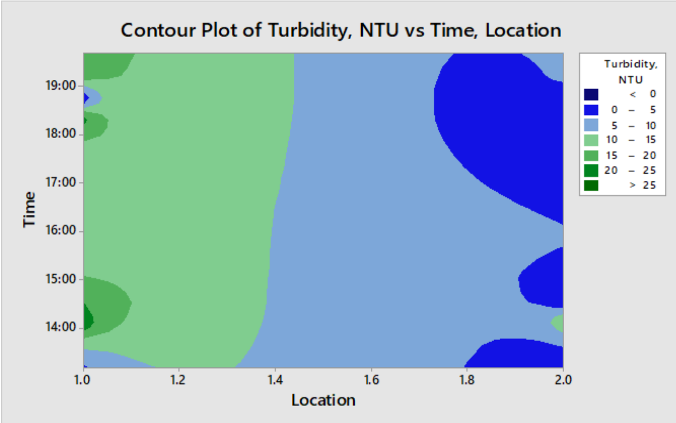
2. METHODOLOGY

The methodology included the collection of secondary and primary data; specifically, a literature review of the effects of construction materials on active sites and the assessment of risk associated with environmental impact and functioning; and a practical exercise involving a physical survey at a site under construction in the Gulf region of the United Arab Emirates. The site in question was selected on the basis of its heavy construction activities and 32 water samples were taken from the water surface at a distance of 12 meters from the active construction site (No.1) and inactive construction site (No.2), and from a depth of less than 20 cm of surface water. The samples were collected over the months of May and June (the hottest months) for four weeks, twice a week at peak construction time, and six hours after the cessation of construction activities, thereby generating 16 samples from each site. Weather conditions including temperature, wind speed, and humidity were recorded, but in this paper, only the temperature data are considered. The sampling method followed the EPA standards requiring all samples to be tested in the laboratory within 24 hours of collection. Turbidity was hypothesized to happen due to suspended particles from construction materials activity, and sedimentation to have resulted from fly ash, slag, and other contents of construction materials that can contribute to turbidity values. Therefore, before testing, samples were shaken properly to ensure that no sedimentation process affected the results, and a turbidimeter was used to measure the turbidity of the samples. The meter measures scattered light at a 90-degree angle from the sample. Water samples were placed in cuvettes for testing. Given the dense internal housing of the cuvettes, the ambient light interference was limited, and thus accuracy was preserved (Fig 1). We also hypothesized that the atmospheric temperature is equal to the Gulf water temperature. However, the difference is not significant since the wind was relatively low, and the depth of sample collection is just a few centimeters deep, thereby showing a closeness between the water's surface temperature and the ambient air temperature. We also assumed that suspended particles and sediments of construction materials lie on the surface of Gulf water. A 500 m distance from Site No. 1 is Site No. 2, selected as the inactive site for comparison and hypothesized as the safest distance for occupied buildings, recreation, fishing, navigation, etc.

Figure 1. Experimental testing of a water sample, and Turbidimeter

3. RESULTS AND DISCUSSIONS

Turbidity values were observed over a period of four weeks for the active construction site, from May to July (the hottest months in the UAE). Variations in humidity levels, temperature, and wind speed were observed throughout the testing period. The contour plot in Fig. 2 shows a comparison between the two locations. Location 1 is an active construction site and Location 2 is at a point 500m away from the construction site and is not exposed to any activities. Turbidity levels were much higher in the water next to the active construction site (Location 1) compared to water away from the construction site (Location 2). Some samples at Location 1 were collected during the construction activity, and some when the construction activity had ceased. The results indicate that the maximum turbidity level (25.2 NTU) was noticed at the construction site during activities when the temperature was 43°C, and the pH was 5.86 while the humidity was 12% (the lowest), and the wind speed was also relatively low (16 km/h). On the other side, the highest turbidity (27 NTU) was observed when the activities stopped in the evening at a temperature of 38°C, when humidity and wind speed were 27%, and 24km/h respectively. However, the turbidity of water away from the construction site was less than 15 NTUs (Fig 3). The measures of turbidity at the active construction site are not beyond the range that meets the water quality designated especially for aquatic life and recreation [14]. In addition, the most severe factor is the temperature which increases turbidity (Fig 4). Noticeably, when considering the effect of temperature on the pH values of the water, as shown in Figure 5, there is not much effect at Site No 2, the location far from the active construction where the pH values ranged between 7 and 8.5 but when considering water samples at Site No 1, the active construction site, the results (shown in Figure 6) reveal more variation in pH values. For the same temperature value, pH varied between 5.5 in some cases and 8.3 in other cases. This can indicate that the water quality near the active construction is more affected. After observing the effect of temperature on water turbidity, it can then also be seen that the higher turbidity value causes higher pH, meaning there is a relationship between heat and pH.



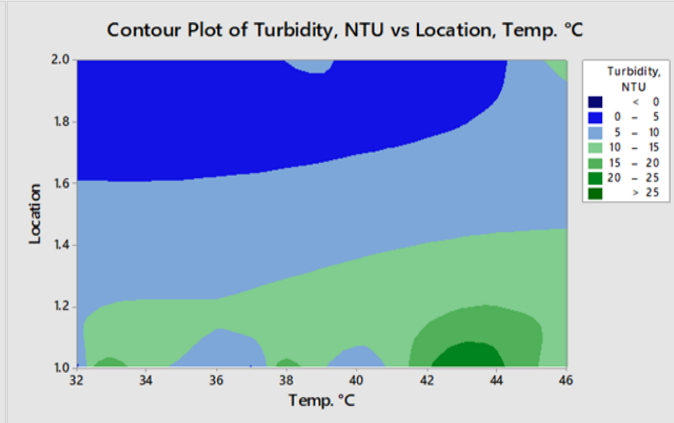


Figure 2. Contour plot of turbidity, time, and locations (1) and (2). **Figure 3.** Contour plot of turbidity vs. location and temperature

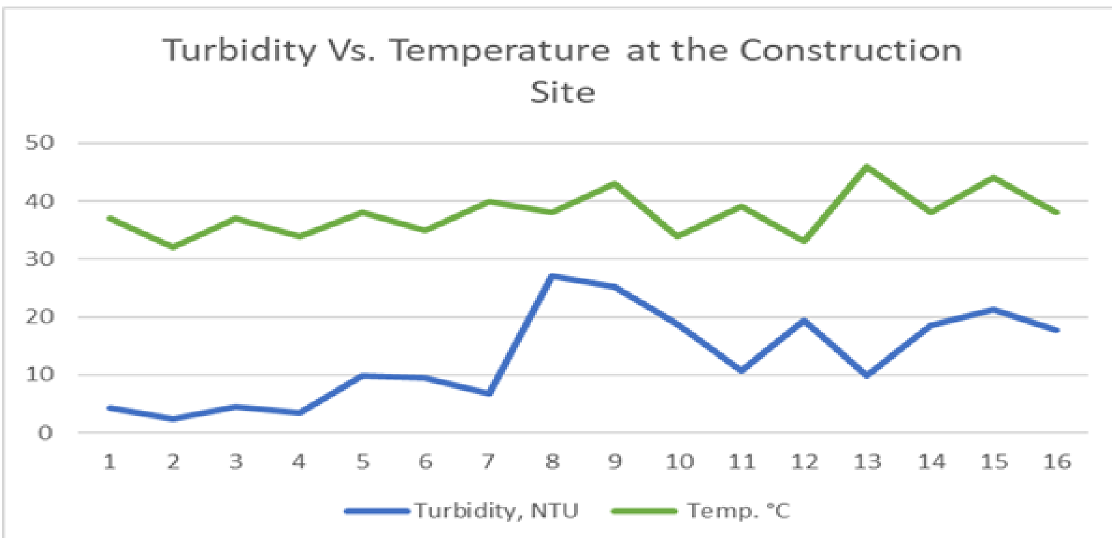


Figure 4. Values of Turbidity Vs. Temperature for water samples

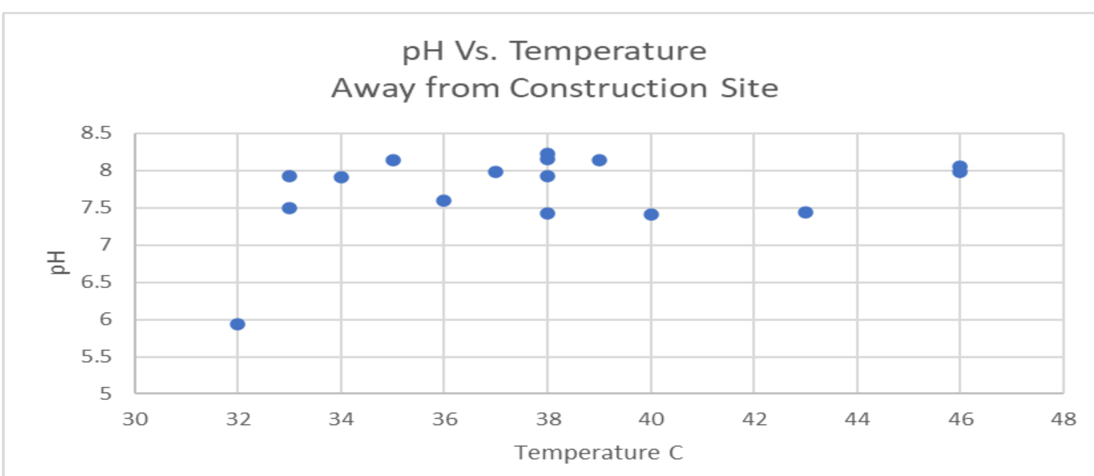


Figure 5. pH Vs. Temperature of Water away from the active construction site

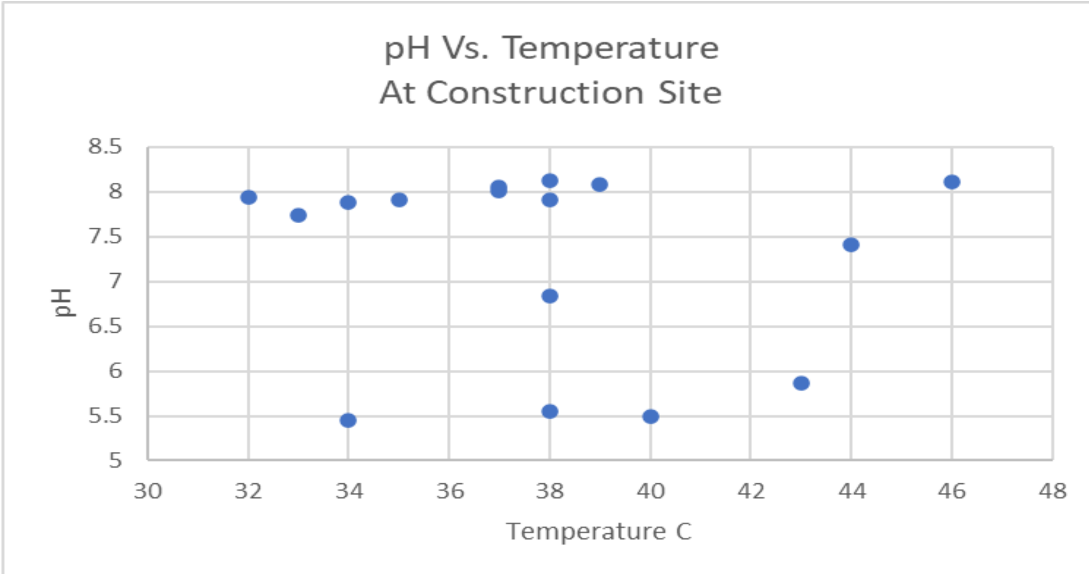


Figure 6. pH Vs. Temperature of water sample at the active construction site

Figure 7 shows the results of the water sample at the active construction site. The effect of turbidity of water was observed on temperature and pH. This pattern was observed for most samples, in some samples (on the far-right side) turbidity was once high when the pH was high and was lower at the same pH value in other samples. This may be considered an error of measurement. The maximum turbidity value was observed when either the temperature was high (above 43°C) and low pH value (around 6) or when the pH was relatively high (around 8) and the temperature was around 38°C. On the other hand, when observing the effect of turbidity on the temperature and pH of water samples away from the active construction site, as shown in Figure 8, it could be seen that the effect of turbidity on pH was observed more, and the temperature was higher (above 44°C). However, turbidity treatment is crucial since pH ranges have been noticed in two sites greater than 6, which makes the turbidity removal need more doses of coagulants.

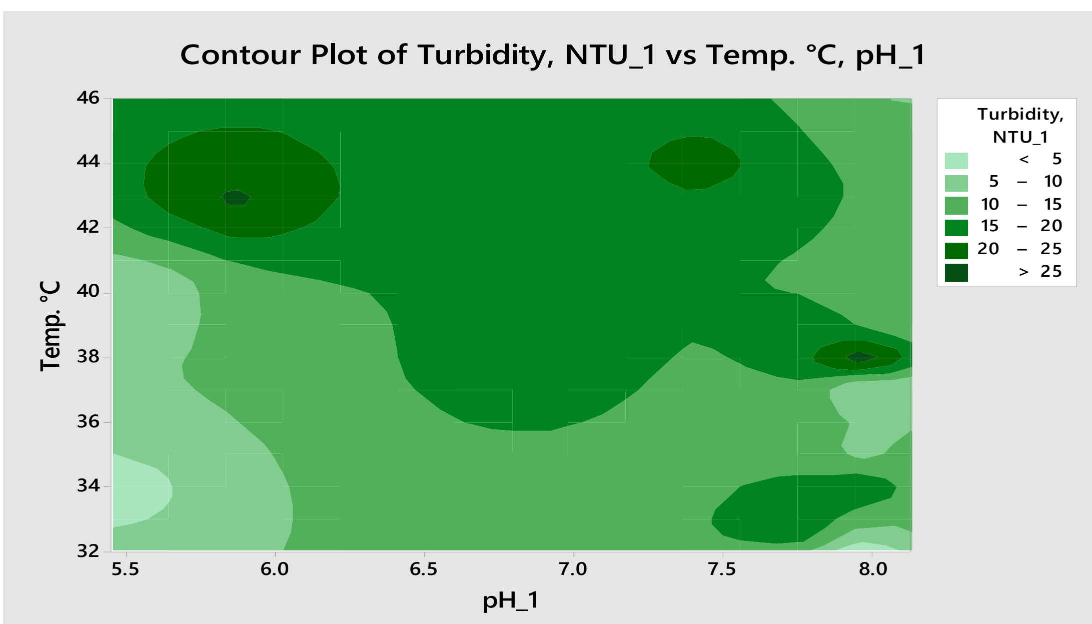


Figure 7. The effect of Turbidity on temperature and pH of water samples at the active construction site.

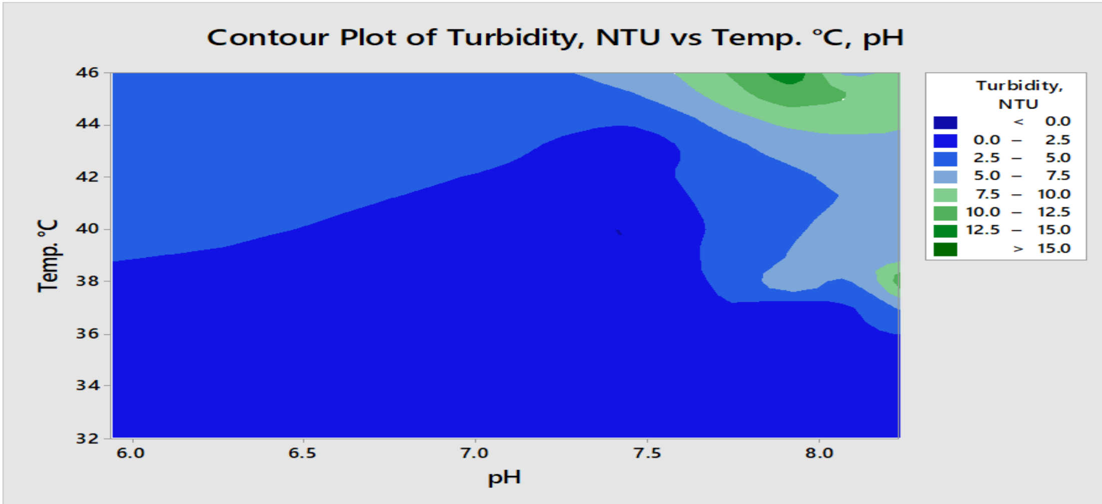


Figure 8. The effect of Turbidity on temperature and pH on the water sample away from the inactive construction site

A Framework for Environmental Risk Management of coastal zones near the Gulf is outlined in Table 1. However, justification versus solutions can be achieved strongly for sustainable development and innovations.

Table 1. Sustainable Development Framework for Environmental Risk Management

Category	Justification vs Solution
Construction materials management	Construction material content (e.g. fly ash and slag binders in cement get dry by temperature and then airborne to the water surface) vs develop green binder materials.
Sustainable management of turbidity treatment	Improve turbidity management vs achievement of maximum removal from water (pH control).
Adaptation of controlling turbidity performance according to EPA regulations	Performance of risk assessment vs a sustainability assessment tool for turbidity treatment (e.g. coagulation, flocculation).
Re-evaluation of environmental risk management research report.	A shortcoming of risk priorities vs auditing of research data for validation.
Statistics Management for communities residing near the Gulf	Considering population increase vs population recreation demands index

CONCLUSIONS

This research study is exploratory in nature, following the authors' knowledge of the high risks to the environment of construction activities near the Gulf. Data was collected from two locations at a distance of 500m from each other. At Site No. 1, there was active construction work whereas at Site No. 2, there was not. The results demonstrated that Site No. 2 (residential area) is projected to be safe for recreation, swimming, fishing, and aqua life since the turbidity levels of water are generally low.

However, turbidity was higher at the active construction location (Site No 1) at a distance of 12m from the Gulf, and this increased during peak activity time and when temperatures between 42°C and 44°C were observed. A major cause of turbidity in the water surface of the Gulf is the suspension of airborne construction materials creating sediments. However, the degree of turbidity was highly correlated with the temperature and pH. As a result, the magnitude of turbidity and pH resulting from construction activities adjacent to the water surface should be continually monitored and managed accordingly. Without proper environmental risk management in this situation, ultimately, turbidity and pH will decrease the quality of life near the water surface over time. Therefore, in an overall framework for such management, attention must be given to construction materials management, sustainable management of turbidity treatment, the adaptation of controlling turbidity performance according to EPA regulations, re-evaluation of environmental risk management research report, and statistics management for communities residing near the Gulf. All these features are significant in a framework that will deliver sustainable development goals according to justification vs solutions.

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