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IMPACT OF SAND MINING ON THE HEAVY METAL CONCENTRATION, IN ISIODU-EMOHUA NEW CALABAR RIVER, RIVERS STATE.

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Abstract

Sand mining has enormous impacts on the environment and the riverine ecosystem in different dimensions. The impacts of the mining activities on the Isiodu rivers despite the continual mining activities have not been ascertained. This study investigated the impact of sand mining activities on the water quality of Isiodu river in Emohua L.G.A. The study adopted an experimental design to examine the impact of sand mining on the level of heavy metals, physicochemical characteristics and the flora and fauna of the ecosystem. The heavy metal levels were determined by the use of Atomic Absorption Spectrometer (AAS), while the standard method was used to determine the physicochemical parameters of the river water. The gill nets and cast nets were used for the fauna while the boat-assisted sampling method was used for deeper water for the flora. The results showed that temperature ranged from 5-97-33.00°C, salinity had a range of 2.13-3.44 mg/L while ITDS has a range of 109.87- 3411.33 mg/L and Nitrate (NO3) was higher than phosphate (PO4). Fe and Mn had the highest levels in all the mining sites. On flora abundant, Syngonsum podophyllu was more abundant at the bridge point, Tribulus terrestris was more abundance with the midpoint and Terminalia spp was more at the last point. While Mudskipper, (Periophthalmus africanus), Crab (Cardiosoma armatum) were more at the bridge point and the Periwinkle (Tympanotonus fascatus) were more at the mid-point and last point, As, had a range of 0.18- 0.22 mg/L, with the highest at last point, Fe had highest level in all the three mining points with a range of 4.95-5.00mg/l followed by Mn with highest levels at the midpoint (1.60+0.12) mg/L. there was no significant difference between Cr, Fe, Mn, Pb, Coper and the three mining point (P>0.05) except As, and Cd that showed a significant differences among the three mining point (P<0.05) the degradation level due to sand mining activities was 12.8m from the original coastal shore. Based on the result, it was recommended that initiating community awareness programme to educate the users and stakeholder about the ecological consequences of mining and promoting sustainable practice. The study concluded that sand mining activities demonstrated significance negative impact on the physiochemical, heavy metal levels, flora, fauna and riparine degradation of the Isiodu river.

***Keyword:** Impacts, sand mining, heavy metals concentration, new Calabar River.*

INTRODUCTION

In recent years, the escalating demand for construction materials and the global surge in urbanization have significantly intensified sand extraction from riverbeds, a practice known as sand mining. Which is essential for infrastructural development, sand mining raises substantial concerns regarding its potential impacts on the environment, particularly the physicochemical and biological attributes of river ecosystems. The impact of sand mining on river water quality and ecology are critical, as they influence not only aquatic life but also human communities that depend on these water bodies, (Nwala, L. & Balafama, G. 2024). This study investigates the impacts of sand mining on the physicochemical and biological parameters of river water, with a focus on the Isiodu community along the Emohua New Calabar River.

Sand mining, as defined by the U.S. Environmental Protection Agency, as the extraction of granulated material resulting "from the natural disintegration of rock or stone" (Harvey, 2018). This anthropogenic activity plays a pivotal role in meeting the global demand for construction material, particularly sand and gravel.

Sand mining can induce multifaceted alterations in river ecosystems, ranging from changes in sedimentation and turbidity to modifications in nutrient levels and habitat degradation (Kondolf, 1997: Padmalal & Maya, 2014). These alterations have the potential to significantly degrade water quality and aquatic biodiversity, necessitating a thorough investigation into the specific dynamics at play in the Emohua New Calabar River. According to the U.S. Environmental Protection Agency (EPA, 1994), sand and gravel are granulated materials resulting from the natural disintegration of rock or stone. These deposits, typically found near the Earth's surface in wet areas. Form the basis of sand mining activities (Harvey 2018). Sand mining, as an activity, involves the extraction of sand from the ground, with a particular focus on natural sand found in shallow waters of rivers (Green, 2019). Nigeria, with Africa's largest population, is undergoing significant urban transformation. Adding complexity to the demand for sand. Urbanization projections estimate an additional 226 million inhabitants by 2050, contributing to a dramatic shift from predominantly rural to predominantly urban living (United Nations, 2014). The social metabolism of sand resources, which refers to the way societies establish and maintain their material input and output to nature, plays a crucial role in resource utilization for urban development (Fischer-Kowalski, 2016). As Nigeria strives to build modern cities, the demand for sand resources has surged emphasizing the need for sustainable mining practices. However, the current situation reveals a concerning trend. Despite its potential benefits, sand mining often fails to deliver expected outcomes, especially in resource-rich but economically disadvantaged regions. The reasons for this failure include problematic deals with mining companies, inadequate monitoring, and lack of enforcement of statutory obligations (Erin et al., 2011). During spatial urbanization the absence of effective regulatory mechanisms has led to unregulated and unethical mining practices, resulting in the degradation of vegetation, alteration of surface topographic, a decline in essential environmental components crucial for human progress and well-being (Oladipo et al. 2014).

A comparison between operator adhering to regulated practices and those engaging in illegal mining highlights stark differences in environmental impacts. Illegal mining, driven by immediate profits, exploits the environment without regard for ethical and procedural norms This observation aligns with findings by Moudgil (2018), who reported the adverse impacts of sand mining on ecosystems. Excessive sand mining not only alters riverbeds but also forces rivers to change course, crudes banks, and leads to flooding, and destroys habitats of macro and microorganisms. Moudgil (2018) further emphasizes the importance of adhering to guidelines on sand extraction, such as proportional removal relative to replenishment rates and river width. The guidelines suggest that mining from a wide floodplain has less impact than mining from a narrow channel. Despite recommendations for manual sand mining over machine usage, weak enforcement, insufficient monitoring, and a lack of environmental education and sensitization for operators contribute to the degradation of river water and its sounding environment.

Types of Sand Mining

1. Riverbed Mining

Riverbed mining involves extracting sand and gravel from river channels, which are typically rich in sediment deposits due to constant erosion and transportation of materials by the river's flow. This type of sand mining is widespread because of the relative accessibility of riverbed deposits. However, it can significantly disrupt the natural morphology of rivers, alter hydrological patterns, and cause riverbank erosion. This erosion, in turn, increases the risk of flooding and can lead to habitat loss for aquatic organisms. Studies show that riverbed mining reduces sediment loads downstream affecting delta formation and altering ecosystems reliant on sediment deposition (Koehnken& Rintoul, 2018).

2. Beach Mining

Beach mining targets coastal sand deposits and is commonly employed for construction purposes and beach nourishment projects, where sand is used to replenish eroded shorelines. However, this practice can lead to severe beach erosion, which in turn destabilizes coastal ecosystems. The removal of beach sand reduces the natural defense against coastal hazards such as storm surges and sea-level rise, thereby exacerbating the vulnerability of coastal communities (Charlier et al., 2005; Hossain et al., 2015). Additionally, beach mining can disrupt turtle nesting sites and damage marine ecosystems, such as coral reefs and seagrass beds, which are crucial for maintaining biodiversity (UNEP, 2019).

3. Dune Mining

Dune mining involves the extraction of sand from coastal dune systems, which play a vital role in stabilizing shorelines and preventing coastal erosion. Dunes act as barriers to wind and wave action, protecting inland areas from storm damage. The removal of sand from dunes can destabilize these systems. leading to the loss of unique habitats and increased susceptibility to storms and erosion (Nordstrom, 2000). Moreover, dune ecosystems host specific flora and fauna adapted to the harsh conditions of sandy environments, and mining activities can lead to the extinction of these species.

4. Inland Sand Mining

Inland sand mining occurs in non-riverine environments, including deserts or areas with significant sand deposits, where mining is conducted far from coastlines or riverbeds. While inland sand deposits are abundant, their extraction can result in habitat destruction and the transformation of landscapes. The removal of large quantities of sand from inland areas can alter local ecosystems, disrupt hydrological cycles, and negatively affect wildlife. Inland mining activities, particularly in arid regions, also risk exacerbating desertification and soil degradation (Bendixen et al., 2019).

Statement of the Problem

In the wake of escalating global demand for sand driven by the rapid pace of urbanization and infrastructure development, the practice of sand mining has become increasingly prevalent. While the extraction of sand is indispensable for meeting the demands of construction, it brings forth a critical challenge that warrants attention, particularly in the context of the Isiodu Emohua New Calabar River. The overarching problem at the core of this study is the insufficient comprehension of the repercussions of sand mining on the physicochemical

parameters, pH levels, and heavy metal concentrations in the river water. One of the primary concerns is the potential alteration of water quality resulting from sand mining activities. The extraction process has the capacity to modify key physicochemical aspects of river water, including parameters like turbidity, dissolved oxygen, and nutrient levels. Despite the significance of these alterations, their extent and implications for the overall water quality of the Isiodu Emohua New Calabar River remain inadequately explored.
Another facet of the problem lies in the potential impact of sand mining on physicochemical characteristics of the river. The extraction process may introduce substances that can influence the pH of the water. However, the exact nature of these pH fluctuations and their consequences for the aquatic environment, including potential effects on aquatic flora and fauna, remains insufficiently understood. Furthermore, there is a concern regarding the introduction of heavy metals into the river ecosystem due to sand mining activities. The specific heavy metals involved, their concentrations, and the pathways through which they enter the ecosystem are yet to be comprehensively investigated. This introduces a risk to aquatic life and, consequently, to human populations reliant on the river for various purposes. The potential cascading effects on the ecological health and biodiversity of the Isiodu Emohua New Calabar River, stemming from the disruption of physicochemical parameters. pH, and the introduction of heavy metals, form another dimension of the problem. The implications for aquatic species, habitats, and the overall balance of the ecosystem remain significant but are yet to be thoroughly explored.
Moreover, this issue has broader implications for sustainability and community well-being. Understanding the environmental consequences of sand mining is pivotal for developing sustainable resource management practices. This includes safeguarding water quality. protecting the livelihoods of communities dependent on the river, and informing policies that strike a balance between developmental needs and environmental conservation. In essence, the knowledge gap around the specific environmental challenges posed by sand mining in the Isiodu Emohua New Calabar River calls for a comprehensive investigation. Addressing these gaps is crucial for formulating effective environmental management strategies, sustainable resource extraction policies, and the conservation of the river ecosystem. This study aims to examine the impact of sand mining activities on the physicochemical, heavy metal concentrations and biological parameters of the Isiodu Emohua New Calabar River, contributing to the broader discourse on responsible and sustainable development.

Aim and objectives of the Study

The aim of the study was to investigate the impact of sand mining on the physicochemical heavy metal level and flora and fauna abundance in the Isiodu River in Emohua L.G.A Rivers State.
Specifically, the objectives of the study are to:
1. Examine physicochemical parameters of river water in sand mining sites.
2. Examine the impact of heavy mental concentration of the water in the sand mining river sites

Significance of the Study

This study is of great significance for understanding the environmental consequences of sand mining in the Isiodu Emohua New Calabar River, offering insights that will benefit a wide range of stakeholders:
1. **Local Communities and Human Health**: The findings of this study will be crucial for local communities that depend on the river for drinking water, agriculture, and domestic purposes. By identifying how sand mining affects water quality and potentially introduces heavy metals, the study provides essential information for safeguarding the health and

well-being of these populations. This enables informed decision-making to protect communities reliant on the Isiodu Emohua New Calabar River.

2. **Miners and the Sand Mining Industry**: For those directly involved in sand mining activities, including miners and industry operators, this study will offer insights into the long-term environmental impact of their work. The findings will help them adopt sustainable mining practices, minimizing the negative effects on ecosystems while ensuring compliance with environmental regulations. Promoting eco-friendly practices can also enhance the social and environmental responsibility of the industry.
3. **Regulatory Agencies and Policymakers**: The research findings will support regulatory agencies, government bodies, and environmental organizations in crafting evidence-based policies and regulations governing sand mining. These stakeholders can use the study to implement balanced regulations that ensure sustainable extraction while mitigating environmental damage. Effective policies could help minimize the ecological footprint of sand mining and safeguard water quality, biodiversity, and ecosystem health.

Scope of the Study

The study was geographically focused on the Isiodu Emohua New Calabar River, providing a detailed examination of the specific environmental dynamics of this region. The insights gained will be applicable to similar river ecosystems facing sand mining challenges. The research scope encompasses an in-depth analysis of physicochemical parameters, including but not limited to turbidity, dissolved oxygen, and nutrient levels. Understanding the alterations in these parameters is crucial for gauging the overall health and quality of the river water. The study investigates the influence of sand mining on pH levels in the river. pH is a critical parameter that affects the entire aquatic ecosystem, and understanding its fluctuations is vital for assessing the potential impacts on aquatic life and ecosystem health. The research will identify the types of heavy metals present, their concentrations, and the pathways through which they enter the river ecosystem. This comprehensive approach provides a holistic understanding of how sand mining influences the Isiodu Emohua New Calabar River's ecological balance.

Area of Study

The study was carried out in an area known as the Emohua extension of the New Calabar River, popularly called the Choba Bridge. The study area is situated in Emohua local government area being demarcated by long span of the river through east and west. In order to adequately utilize the area and to study variations, the research study will be carried out in three (3) selected stations and or points namely: Bridge point, Mid-point and Last point with representative initials as Bp, Mp and Lp respectively. The area of study is the Emohua extension of the "New Calabar River". The long span of the river split across three (3) local governments by boundaries. Emohua Local Government is bordered from East by Obio/Akpor LGA, West by Ahoada-East LGA, North by Ikwerre LGA and South by Akuku-Toru LGA with area covering approximately 831 Km^2. The National Population Commission holds a population of approximately 201,901 for Emohua LGA and is located between latitudes of 4° 5'0" N. and longitudes 6° 52'0" E respectively with average elevation below 30 meters. Above sea level. Its geological structure comprises basically of alluvial sedimentary basin and basement complex. Its vegetation is characterized by a mix of mangrove and coastal swamp forests, raffia palms and tight rainforest. Due to high rain fall, its soil is usually characterized as sandy or sandy loam.

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Results

The results of the physicochemical characteristics of water in the mining site reflecting the impact of mining at various points along the site.

Table 1: Physicochemical parameter of the mining site

FACTOR	MINING POINTS				
	Bridge point	MidPoint	Last point	F	P
Ph	6.0±.10	6.04± .05	0.05 ±0.06	4.02	0.08
Temperature	5.97±0.17	33.00±0.70	32.80±0.02	0.17	0.85
Turbidity	32.90 ±0.35	5.37 ±0.11	5.47 ±0.02	3.72	0.09
Conductivity	5.29±1565.13	4006.67±4.73	4875.67±1146.92	7.14	0.03
Salinity	3475.56 ±0.99	2.13 ±0.01	2.62 ±0.01	6.25	0.03
TDS	1.92 ±1095.87	2805.00±1.53	3411.33 ±4.16	6.81	0.03
Dissolved oxygen	2586.56 ±0.06	6.77 ±0.02	6.71 ±0.01	2.48	0.16
BOD	6.73 ±0.61	5.73 ±0.05	6.46 ±0.05	4.72	0.06
Nitrate(NO_3)	6.25 ±0.06	0.19 ±0.05	0.19 ±0.01	1.54	0.29
Phosphate(PO_4)	0.21 ±0.00	0.05 ±0.01	0.06 ±0.01	1.50	0.30

Key: pH. TDS= Total Dissolve solid, BOD, Bio Oxygen DemandF =P,S=Significant

Heavy metal concentrations in the mining site

The concentration of Pb ranged from 0.05- 0.07 mg/L. The highest mean concentration was observed at the Mid-Point. Cr levels ranged from 0.03-0.05 mg/L. The Last Point exhibited the highest mean concentration of Cr. Cd concentrations were quite low, ranging from 0.002-0.003 mg. Fe showed a wider range of concentrations, from 1.5 1.8 mg/L, with the Mid Point having the highest mean concentration. Cu ranged from 0.08-0.10 mg/l. with the Last Point exhibiting the highest mean concentration. Manganese had a mean concentration ranged from 0.9 1.0 mg/L, with the Mid Point showing the highest mean concentration and Arsenic concentrations were low, ranging from 0.01-0.015 mg/L at the Mid-Point, where the highest mean concentration was recorded. Mid-Point consistently exhibited the highest mean concentrations for most of the metals, including Pb, Cd, Fe, Mn, and As, suggesting it may be impacted by sand mining activities. The concentration ranges for most metals were narrow, indicating minimal fluctuations across the three estations, with Ireon (Fe) showing the greatest variability. Iron (Fe) had the highest overall concentration range, while Cadmium (Cd) and Arsenic (As) were found in trace amounts, maintaining consistently low level.

Table 2: Heavy metal concentration (mg/1) of the three different points at the mining site

Heavy Metal (mg/1)	MINING POINTS Bridge point (Mean ±SD)	Mid-Point (Mean ± SD)	Last point (Mean ± SD)	F	Pe	S
As	**0.20** ± 0.02	0.18± 0.03	0.22 ± 0.01	402	0.04	S
Cr	1.20 ± 0.10	1.10 ± 0.15	1.25 ± 0.12	1.50	0.02	NS
Cd	0.05 ± 0.01	0.06 ± 0.02	0.04 ± 0.01	1.52	0.03	S
Fe	2.01 ± 0.50	5.10 ± 0.45	4.95 ± 0.55	4.07	0.06	NS
Mn	1.50 ± 0.10	1.60 ± 0.12	1.55 ± 0.15	2.47	0.07	NS
Pb	0.10 ± 0.01	0.15 ± 0.02	0.12± 0.03	3.02	0.09	NS
Cu	0.30 ± 0.05	0.35 ± 0.062	0.32 ± 0.05	1.58	0.07	NS
Sig	S	S	S			

Key: As- arsenic, Cr- Chromuim, Cd- Cadmium, F-Iron, Mn-Mangansee, Pb-Lead, Cu-Coppers

Abundance of flora in the mining site

Table 2 displays the result of the flora distribution within the mining site. Lupines had the highest mean last point; Crinum had a mean range of 1.00 -1.67 with the last point as the highest. Date palm exhibited a mean range of 1.33- 2.00 with the last points having the highest, Pandans had the highest mean last points. Terminalis recorded the highest at the last point. Paspalum showed a means range of1.33-2.33. Reeds had a means range of 0.67-2.00. Puncture vine showed highest mean values at midpoint. Arrowhead plant had a mean range of. 2.00-3.00 with the highest at the last point. The results further indicated no significant difference in the distribution of flora between the bridge (p = 0.279) and last point (p= 0.809). However, a significant difference (p = 0.028) was observed in the distribution of florat the midpoint in the mining site.

Discussion of findings

The results presented in Tables 1 and 2 shed light on the multifaceted impact of sand mining activities on the river ecosystem, encompassing physicochemical parameters, flora and fauna abundance, and coastal degradation. The observed variations in physicochemical parameters, such as pH, temperature, turbidity, salinity, and total dissolved solids (TDS), reflect the intricate response of the river to sand mining activities. These alterations in water quality are in line with previous studies by Moudgil (2018) that highlighted the impact of sand mining on rivers and aquatic environments Harvey (2018) also explained that excessive turbidity, as indicated in the results, is known to adversely affect aquatic ecosystems by limiting light penetration and disrupting the habitat of aquatic organisms (Moudgil, 2018). The observed changes in pH and salinity also align with findings in literature, emphasizing the sensitivity of these parameters to anthropogenic disturbances (Erin et al., 2011).
The results of heavy metal concentrations (lead, chromium, cadmium, iron, copper, manganese, and arsenic) across different sampling points provide critical insights into the environmental impact, particularly with possible influences from sand mining activities. This relatively narrow range suggests that lead levels were fairly stable across the three sampling locations. Ali et al. (2019) found that industrial activities, including mining, tend to elevate lead levels in water bodies, though in this study, the levels remain below the WHO guideline of 0.01 mg/L for drinking water, indicating the concentrations could be environmentally significant but may not pose immediate health risks. Similar to lead, chromium levels also showed limited variability, with the Last Point exhibiting the highest mean concentration. Chromium is commonly associated with industrial discharge and natural weathering of minerals as

highlight that chromium contamination in aquatic systems can be harmful, particularly in its hexavalent form (Cr(VI)). Although the concentrations observed here are low, long-term exposure could still present ecological risks, consistent with findings in similar riverine studies. Cadmium concentrations were the lowest of all the heavy metals, ranging from 0.002 mg/L to 0.003 mg/L. Although these values are well below the WHO limit of 0.003 mg/L for drinking water, cadmium's toxic nature, even at trace levels, is a concern for both aquatic life and human health. The higher mean concentration at the Mid-Point aligns with studies by Zhang et al. (2020), which link elevated cadmium levels to industrial activities and mining. These low but persistent levels highlight a need for long-term monitoring.

Iron exhibited the widest range of concentrations, from 1.5 mg/L to 1.8 mg/L, with the Mid Point again showing the highest mean. Iron concentrations fluctuated more than other metals, suggesting variable sources, such as both natural soil erosion and human activities, including mining and agricultural runoff. According to Moyo et al. (2019), elevated iron levels are commonly found near mining areas, and while iron is not as toxic as other heavy metals, high concentrations can affect aquatic life and water quality by promoting excessive algal growth and oxygen depletion.

Copper levels ranged from 0.08 mg/L to 0.10 mg/L, with the Last Point showing the highest concentration. The stability of copper concentrations across the points is noteworthy, as Cu is commonly used in agricultural practices and can enter water bodies through runoff.

Manganese concentrations varied between 0.9 mg/L and 1.0 mg/L, with the highest mean at the Mid- Point. Manganese is often naturally present in water due to the dissolution of 20 minerals and is typically not considered as hazardous as lead or cadmium. However, at elevated levels, it can affect the taste and appearance of water. The moderate fluctuations observed in manganese concentrations may suggest that natural sources contribute more significantly to its presence than anthropogenic activities. Arsenic concentrations were consistently low, ranging from 0.01 mg/L to 0.015 mg/L. The Mid Point recorded the highest mean concentration. Arsenic is a known carcinogen, and its presence in water bodies, even at trace levels, is concerning. The observed concentrations are below the WHO limit of 0.01 mg/L, but the higher concentrations at the Mid-Point could point to localized contamination. Possibly linked to sand mining or natural arsenic-bearing mineral dissolution. The Mid-Point consistently exhibited higher concentrations of most metals, particularly lead, cadmium, iron, manganese, and arsenic. This trend may indicate that the Mid Point is more heavily impacted by sand mining activities compared to the other locations. The overall narrow ranges of metal concentrations, aside from iron, suggest minimal fluctuations, which could be attributed to either constant pollution sources or consistent natural processes. Iron's wider range could be linked to more dynamic interactions between natural and human-induced factors, as found in similar environmental studies (Nduka & Orisakwe, 2016).

The abundance patterns of flora and fauna species in the mining site provide valuable insights into the ecological resilience and vulnerabilities associated with sand mining. The increase in Lupines abundance and the resilience of certain flora species, such as Crinum and Date Palm, might be indicative of adaptive strategies developed by these species in response to altered environmental conditions (Harvey, 2018). However, the decline in the abundance of Mudskipper and Watersnail suggests that certain species may be particularly sensitive to the disturbances induced by mining activities (Erin et al., 2011). Similarly, the findings regarding fauna abundance unveil the nuanced responses of various aquatic organisms to sand mining.

CONCLUSION

In conclusion, this study highlights the profound impact of sand mining on river ecosystems. The observed increases in turbidity, changes in pH and salinity, and river bank erosion underscore the significant disruptions caused by mining activities. These findings align with established literature, emphasizing the urgent need for effective monitoring and sustainable practices. The varied responses of flora and fauna reveal both resilience and vulnerability. underscoring the necessity for a holistic conservation approach. The measured river bank degradation further highlights the pressing need to reassess extraction methods and implement sustainable measures to protect river ecosystems. The interconnected nature of physicochemical parameters, flora and fauna responses, and coastal degradation emphasizes the need for a unified approach to environmental management. As sand remains a crucial resource for various industries, responsible mining practices must be prioritized to ensure the longevity and resilience of river ecosystems.

RECOMMENDATIONS

Based on the findings, the following are recommended:

1. Strengthening and enforcing robust regulatory frameworks to guide sand mining activities, ensuring adherence to environmental standards.
2. Implementing effective monitoring mechanisms to track changes in physicochemical parameters, flora and fauna dynamics, and coastal morphology.
3. Initiating community awareness programs to educate stakeholders about the ecological consequences of sand mining and promoting sustainable practices.
4. Encouraging further research to deepen our understanding of the long-term impacts and potential mitigation strategies.

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