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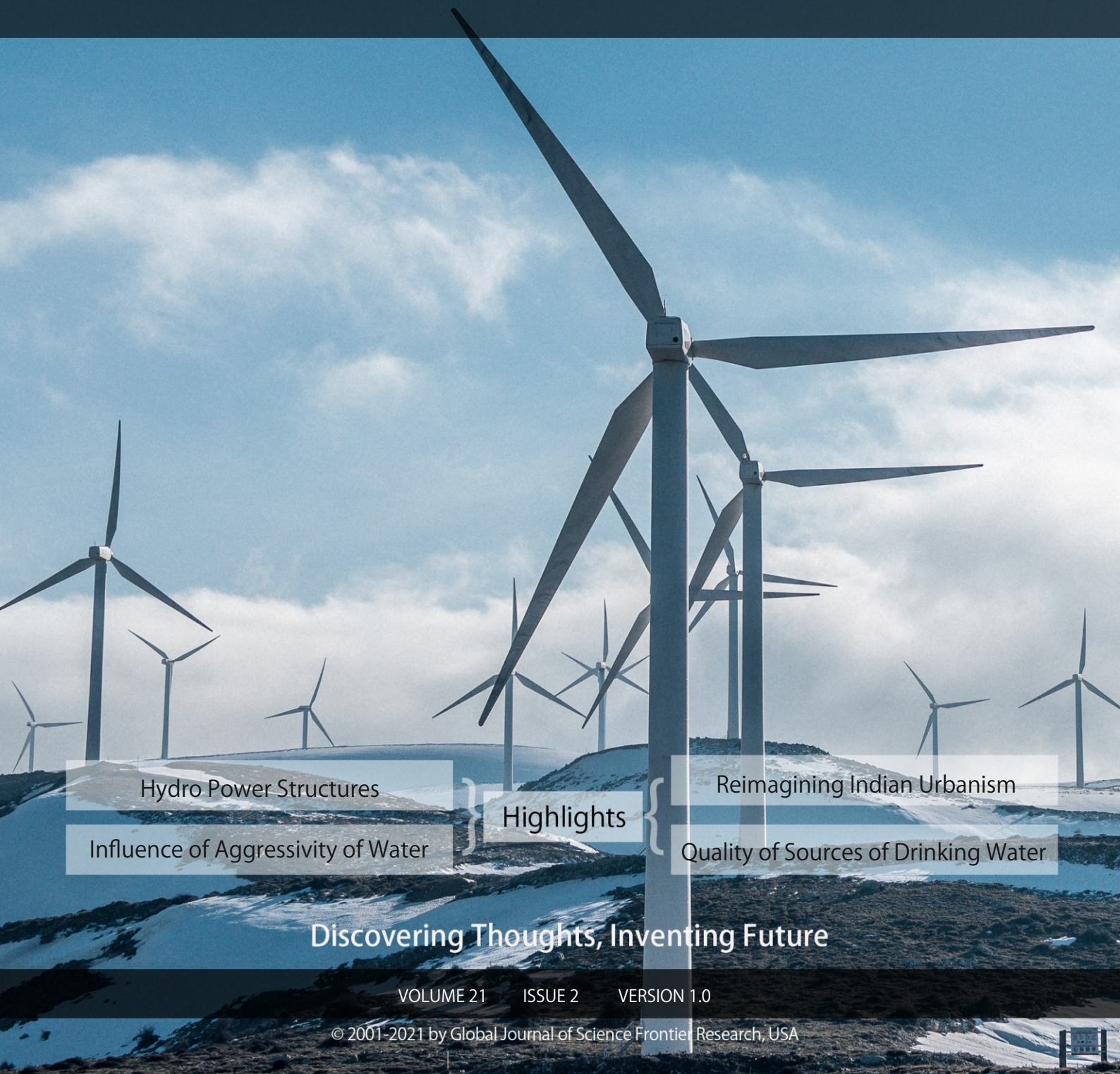

Hydro Power Structures

Influence of Aggressivity of Water

Highlights

Reimagining Indian Urbanism

Quality of Sources of Drinking Water

Discovering Thoughts, Inventing Future

VOLUME 21 ISSUE 2 VERSION 1.0

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Influence of Aggressivity of Water on the Long Term Sustainability of Hydro Power Structures – A Review

By Beena Anand

Abstract- To fulfil country's irrigation and power requirements various large capacity dams have been constructed on major rivers in last 50 years. The long term sustainability of these structures is largely dependent on hydro-environment and the capacity of these structures to resist weathering action, chemical attack, abrasion, or any other process of deterioration. The concrete deterioration is directly influenced by various geographical, climatic and ecological conditions. The chemical reactions between cement and water enable the setting and hardening of cement, resulting in a binding medium for the aggregates and development of strength. Quality of water plays an important role in the production of concrete. There are some chemical environments under which the useful life of even the best concrete will be affected adversely. The aggressiveness of water is dependent on the pH value, the total dissolved salts, the degree of hardness, soluble chlorides, sulphates, carbonation, temperature and alkalinity etc. Understanding these conditions permit measures to be taken to prevent or reduce deterioration.

Keywords: aggressivity; durability, leaching; seepage; hydro-environment.

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Influence of Aggressivity of Water on the Long Term Sustainability of Hydro Power Structures – A Review

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Abstract- To fulfil country's irrigation and power requirements various large capacity dams have been constructed on major rivers in last 50 years. The long term sustainability of these structures is largely dependent on hydro-environment and the capacity of these structures to resist weathering action, chemical attack, abrasion, or any other process of deterioration. The concrete deterioration is directly influenced by various geographical, climatic and ecological conditions. The chemical reactions between cement and water enable the setting and hardening of cement, resulting in a binding medium for the aggregates and development of strength. Quality of water plays an important role in the production of concrete. There are some chemical environments under which the useful life of even the best concrete will be affected adversely. The aggressiveness of water is dependent on the pH value, the total dissolved salts, the degree of hardness, soluble chlorides, sulphates, carbonation, temperature and alkalinity etc. Understanding these conditions permit measures to be taken to prevent or reduce deterioration.

Some case studies related to some peculiar problems encountered during the pre and post construction investigations with special reference to deterioration of concrete due to highly acidic water quality faced at Kopili H.E. Project, Lower Kopili HE Project and Myntdu HE project, all the projects located in North Eastern part of India are presented in this review. A brief discussion on the findings of filed observations made in recent past by the CSMRS over the environmental aspects of water quality and its detrimental effects already caused on structures has also been done. Few remedial measures for the upgradation of catchment area to control the acidification of rivers are also discussed here.

Keywords: aggressivity; durability, leaching; seepage; hydro-environment.

I. Introduction

These are the three projects facing a lot of problems due to very low acidity of river water. These are Kopili HE Project, Lower Kopili HE Project (both in Assam) and Myntdu Leska HE Project located in Meghalaya. Studies for the two projects viz Lower Kopili HE Project and Myntdu- Leska HE Project were done at the DPR stage of the projects while for Kopili HE Project the study for the damages due to acidic environment was done post commissioning of the project. All the three projects are located in the nearby area of Jaintia Hills region of Meghalaya, one of the seven north eastern states of India possesses rich deposits of coal at relatively shallow depth. Coal found in this area contains high sulphurous content. The state being a Sixth Schedule State, its autonomy gives freedom to the people to mine at their own will. Most of the mining activities are small scale units controlled by individuals who own the land. Mining operations has led to extensive environment degradation in the area. For assessing the impact of coal mines the catchment area of rivers Myntdu, Laichiki, Lamu, Makjai, Umshangphu, Khakar and Kopili which flow through the coal rich belt of the state has been surveyed. The rivers Myntdu, Laichiki, Lamu, Makjai, Umshangphu impound the reservoir of Myntdu-Leshka Hydro Electric project while rivers Khakar and Kopili impound the twin reservoirs of Kopili Hydro Electric project.

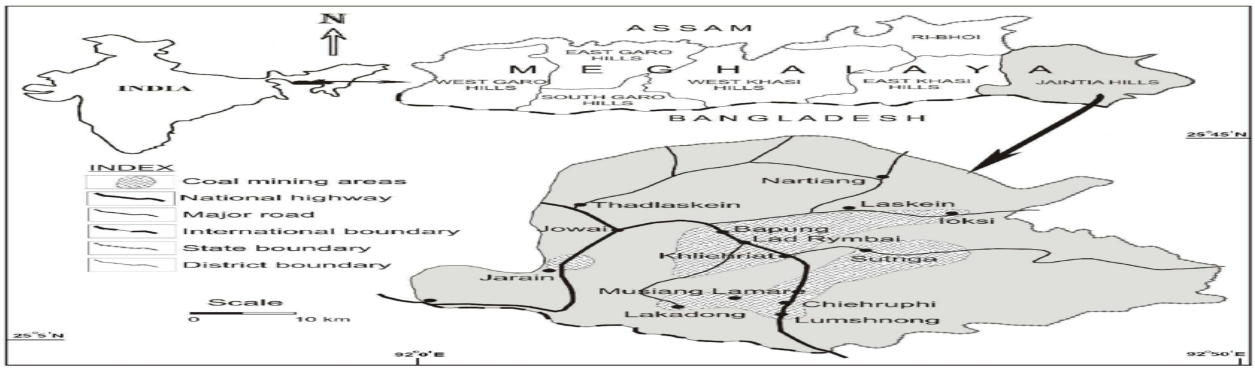

Figure 1: Outline map showing the coal mining areas in Jaintia Hills of Meghalaya in northeast India

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On the request of Project Authorities, CSMRS took the investigation work. The thrust area of in situ & laboratory water quality studies of river Kopili & its tributaries was:

- To assess the water quality to ascertain its long term effect on durability of dam concrete structures.
- To investigate acidity problem of river Kopili at Dam axis, powerhouse site and adjoining Nallahs & possible remedial measures thereof.

Acid attack deteriorates concrete and steel components of project, and plays a major role towards the high cost of it in a number of ways. Some of the photographs below in *Figure 2* show the small scale rat-hole mining abandoned mines filled with rain water causing the acidification of river water.

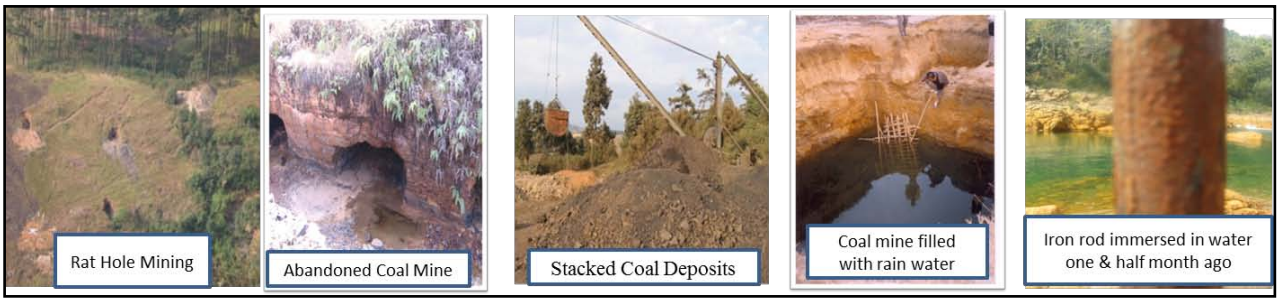

Figure 2: Rat-hole mining, abandoned mines filled with rain water causing the acidification of river water

During the field visit (s), the in-situ parameters like pH, conductivity and temperature of water samples were recorded along with the visual impact of aggressive water on the river water, boulders etc. At some stretches, pH of river water was recorded as low as 3.65. Photographs below in *Figure 3* showing the impact of aggressive water on the river water, boulders etc.

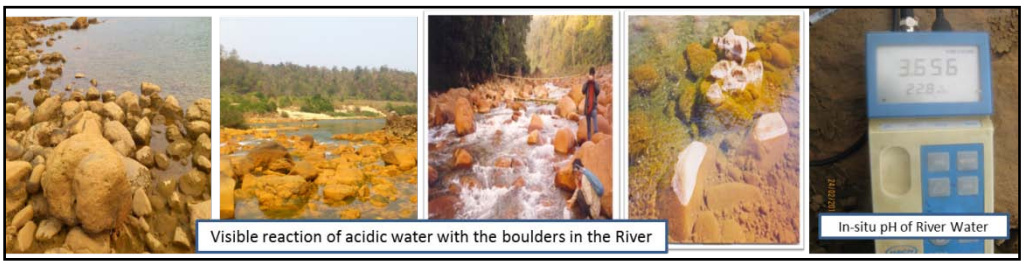

Figure 3: Impact of aggressive water on the river water, boulders

Figure 4 shows the signs of distress observed in the concrete structure and various other components of Kopili HE project due to acidic water impounded in reservoir and used for power generation.

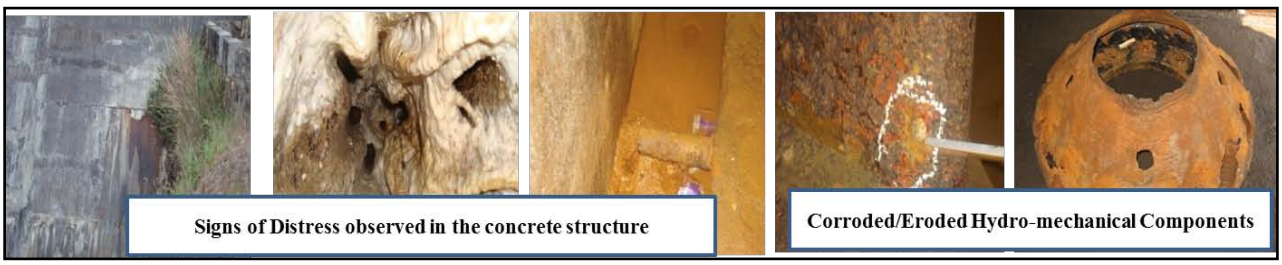

Figure 4: Signs of distress observed in the concrete structure and various other components

II. Problem Encountered

The richness of Jaintia Hills region in minerals is posing the most serious problem as the rivers flowing through the area have turned acidic with very low pH, making them "unfit" for human consumption, hence the population is reeling under thirst around the region of plenty of water. Also the vegetation, flora and fauna, particularly the aquatic life, has also been suffering because of low pH of rivers of the area [1]. Mining is done by private people at their wish and the state government has no control over the rich coal lobby [2]. Most of the time coal mines in Jaintia Hills are abandoned after extracting the mineral. Heavy metals are left exposed which subsequently react with water/oxygen to form different chemicals. Due to heavy

rains in the area, these harmful chemicals make their way to fresh water bodies causing a number of problems due to acidification and pollution of rivers and streams. Though scientists and environmentalists all along have been raising fingers at the unscientific coal mining practiced in Jaintia Hills, yet success of seems be far away.

Up to year 2006 after commissioning of its first stage in 1984 of Kopili HE Project, the project has been continuously serving the region smoothly by providing electric energy. Frequency of outages was rare till year 2006 which suddenly increased abruptly. Further investigations revealed that water in the reservoir has turned acidic. During post outage maintenance it was detected that the reason of outages was corrosion/erosion of hydro-equipment. The risk of exposing hydraulic structures and equipment to unforeseen aggressive environment which is pushing the plant to a perilous situation necessitated detailed investigation of the problem.

a) Acidification of water due to mining activities: Acid Mine Drainage (AMD)

Basically two processes namely Acid Mine Drainage (AMD) and Acid Rock drainage (ARD) are responsible for the acidification of River/stream/Oceanic water [3]. Acid mine drainage (AMD) refers to the outflow of acidic water from a mining site. In most cases, this acid comes primarily from oxidation of iron sulfide (FeS_2, also known as pyrite or "fool's gold"), which is often found in conjunction with valuable metals Acid mine drainage is a major problem with many hard rock mines, including almost all mines where the metal ore is bound up with sulfur (metal sulfide mines). A significant number of coal mines also suffer from acid mine drainage. Acid mine drainage is a worldwide problem, leading to ecological destruction in watersheds and the contamination of human water sources by sulfuric acid and heavy metals, including arsenic, copper, and lead. Once acid-generating rock is crushed and exposed to oxygen and the surface environment, acid generation is very difficult to contain or stop, and can continue for tens or thousands of years until the available sulfide minerals are exhausted. Presence of certain bacteria e.g. Thiobacillus ferrooxidans and Thiobacillus thioxidans promote sulphur and/or iron oxidation (Corrans et al., 1972).

b) Biological Factors for the acidification of Water Bodies

In situations where bacterial acceleration of sulphide oxidation is significant (principally at low pH), the bacterial population density and rate of population growth determine the bacterial activity and the rate of acid generation. Population density and growth of bacteria are a function of a number of factors such as carbon availability (in the form of carbon dioxide), presence of electron donor (ferrous iron or sulphur), nutrient availability (i.e., nitrogen, phosphorus for production of biomass), oxygen (promotes growth of aerobic bacteria and is an electron acceptor; kills strictly anaerobic bacteria) and temperature (most bacteria demonstrate optimal growth below approximately 70°C).

Virtually sulphur and iron are omnipresent at mining sites. Microorganisms are highly efficient in manipulating their immediate environment, either at their own or in a symbiotic relationship with other microorganisms. Hence, the actual reaction site environmental conditions is more conducive to elevated oxidation rates than it is predicted by measurements in the bulk liquid phase. [4].

Certain bacteria accelerate the rate of reactions of sulphide oxidation. Bacteria of the *Acidithiobacillus* species are of particular importance with regard to sulphide oxidation. *A. ferroxidane* is capable of catalyzing both the oxidation of sulphur and ferrous iron while *A. thiooxidanes can* oxidize sulphur only. Other members of the *Acidithiobacillus* species are also capable of catalyzing pyrite oxidation like certain members of the genera *Sulfolobus* and *Lepto-spirillium.* [5].

c) Water Quality Investigation

Initially the investigation work of Myntdu-Leska HE, Meghalaya project was done for its DPR. The high acidic nature of Myntdu River was established by conducting detailed field and laboratory analysis of water samples. In the meanwhile already constructed and operational Kopili HE Project, Assam started facing troubles in operation and frequent outrages were reported after 2006. Investigation revealed the similar high acidic nature of Kopili River as that of Myntdu River. Thn came the Lower Kopili HE Project on the Kopili River for its DPR studies.

Water quality investigation was carried out for three different seasons viz pre-monsoon, post monsoon and lean season to access the water quality and its impact on the long term durability of concrete and other equipment. Water samples were subjected to both in-situ and detailed laboratory analysis. The in situ and laboratory parameters were determined as per standard analytical procedures laid down in Indian Standard: 3025–1986 "Methods of Sampling and Test (Physical and Chemical) for Water used in the Industry". Wherever necessary, reference was also made to the procedure laid down in Standard Methods for the Examination of Water and Waste Water" published by American Public Health Association and Water Pollution Control Federation, USA, 1985. Water samples collected by CSMRS from the various locations of the catchments show the pH value ranging between 2.76 to 5.98. Coal mining in the catchment area is the main cause of acidity of reservoir water. *Figure 5* below shows very low pH of River water at various stretches of Kopili River.

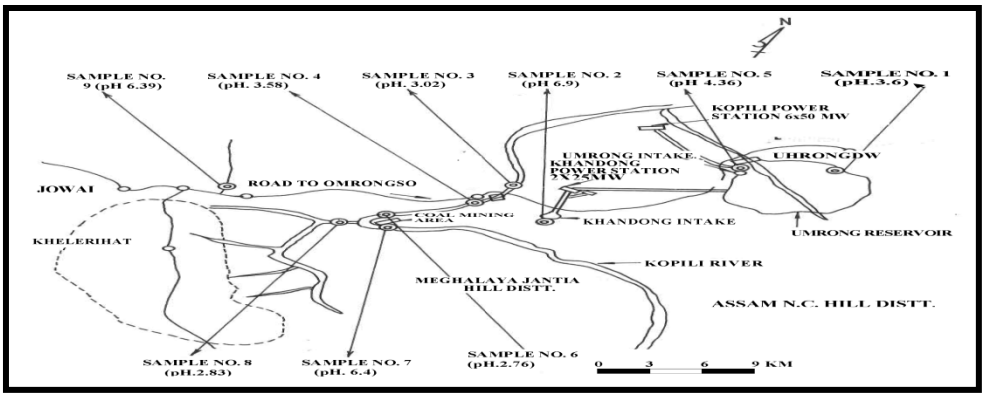

Figure 5: pH at various sampling locations in the catchment area of KHEP

Due to highly acidic nature of water, the deleterious effect on concrete and other hydro-components of structures are possible in the form of:

- Leaching of lime from concrete
- Loss of concrete strength over a period of time
- Possibility of attack on metallic portion e.g. Turbine blades, reinforcement etc.
- As per the BIS code IS: 456 – 2000, environmental conditions are "Extreme" and the requirement of concrete should be as per the codal provisions.

d) Field and Laboratory Analysis

In-situ parameters like pH, $CaCO_3$ saturated pH, conductivity, temperature, salinity, sulfide and ammonium concentration were recorded.

Parameters like cations (calcium, Magnesium, Sodium, Potassium); Anions (Carbonate, Bicarbonate, Chloride & Sulphate) were determined in the laboratory.

e) Degree of Aggressivity of Water

Degree of aggressivity of water is established under the guidelines laid down in following relevant national and international codes and practices:

- United States Bureau of Reclamation Sstandard (USBR) for sulphate aggressivity.
- French National Standard, p18-011, May 1985 for assessing aggressivity due to pH, Ammonium, Magnesium and Sulphate ions.
- International Commission on Large Dams, ICOLD Bulletin No. 71 "Exposure of Dam Concrete to Special Aggressive Waters – Guidelines and Recommendations, 1989" for assessing aggressivity of soft water.
- Indian Standard 456-2000 "Plain and reinforced concrete – Code of practice" (fourth revision).
- Extracts from ACI 515-1R5, Para 2.5, 1991, "Susceptibility of concrete to attack by chemicals" and book titled "Concrete Corrosion, Concrete Protection" Imre Biczok, 1991.

III. Observations & Recommendations

Out of three season's pH observations, the pH values of river locations are noticed in highly acidic range in pre-monsoon (February 2015) water quality observation. In monsoon (June 2016) season, the pH values marginally increases in the range of 6.68 to 7.85. While in post monsoon season (October 2016), pH values become again slightly acidic in the range of 5.49 to 6.15. [Figure 6].

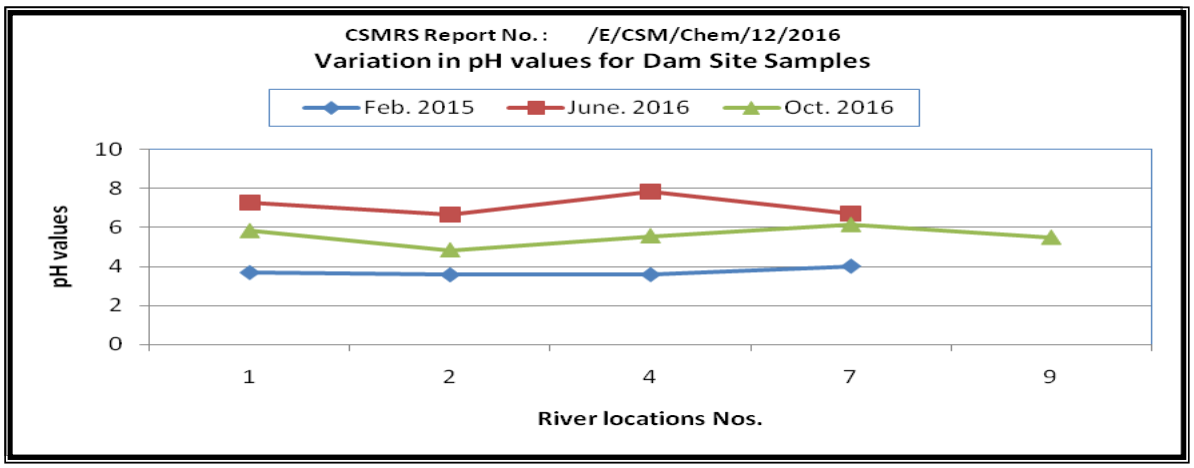

Figure 6: Variation of pH values in different seasons for river water locations

Out of three season's conductivity values, the conductivity values of post monsoon season are noticed in the range 93.7 to 151.2 micromhos/cm. However, the conductivity values remain lower in all seasons in the range of 76.7 to 151.2 micromhos/cm. [Figure 7]

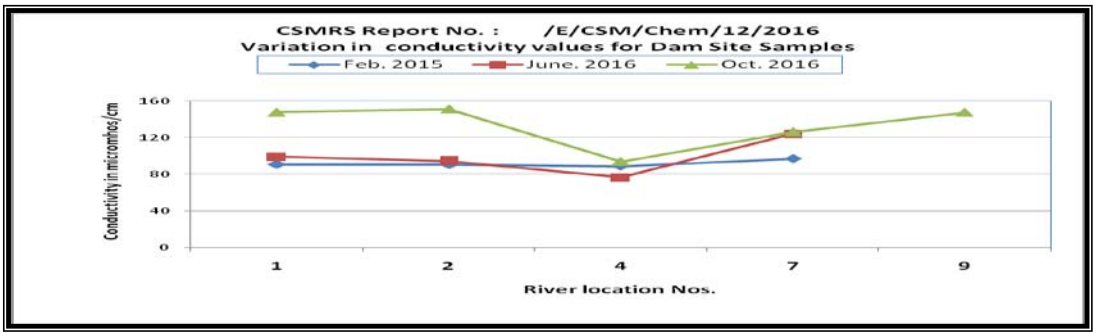

Figure 7: Variation in conductivity values in different seasons for river water locations

The water quality evaluated during pre-monsoon, monsoon and post monsoon seasons for river and Nallah sites. Seasonal variation in pH is appreciable and remains in acidic range for most of river and Nallah locations during pre-monsoon and post monsoon seasons. Further, the type of the water under reference is "soft" (in accordance to calculated Langelier Index Values of water samples) in nature as the conductivity and anions and cations concentrations recorded lower side throughout the period of observations. However, due to discharge conditions, the pH values improve in river and Nallah locations in monsoon season. After the study of the analytical data of the water samples, the observations along with remedial measures suggested are discussed here.

a) Environmental Exposure Conditions

After the evaluation of water quality data for three seasons, the overall water quality of the various sites of the project may be classified as "severe" category as far as its attack on concrete is concerned. The details of various environments are given in Table 3 under clauses 8.2.2.1 and 35.3.2 of Indian Standard: 456 – 2000.

Clauses 8.2.2.1 and 35.3.2 of IS: 456 – 2000

Sl. No.	Environment	Exposure Conditions
i	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet Concrete exposed to condensation and rain ; Concrete continuously under water; Concrete in contact or buried under non aggressive soil/ground water Concrete surfaces sheltered from saturated salt air in coastal area.
iii	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water Concrete exposed to coastal environment
iv	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whiles wet Concrete in contact with or buried under aggressive sub-soil/ground water
v	Extreme	Surface of members in tidal zone Members in direct contact with liquid/solid aggressive chemicals

b) Study of Nature of Coal Samples

During the field survey, it was observed that unscientific way coal mining activity might be undertaking in the catchment area probably using Rat Hole Technology. In this method, after excavation of coal, the holes and pits are generally left open and unattended. As the region receives heavy rains during most of the time of the year, these ditches get filled with rain water. Under the feasible/favourable conditions, left over coal reacts with water and in turn as a result sulphuric acid is produced and the acidic water finds its way into the river. The interaction of water with coal mine lowers the pH of the water, when the river water becomes stagnant.

To ascertain the effect of interaction between coal and water with respect to change in pH, conductivity and sulphate concentration, a study was carried out. Coal samples were collected from the coal mines located in the catchment area of Myntdu River (Sample 1) and Kharkor River (Sample 2). These

samples were kept in distilled water. The pH, conductivity and sulphate concentration values of the supernatant liquid were recorded till 180 days. The results of these observations are depicted in the Figures 8, 9 and 10 below:

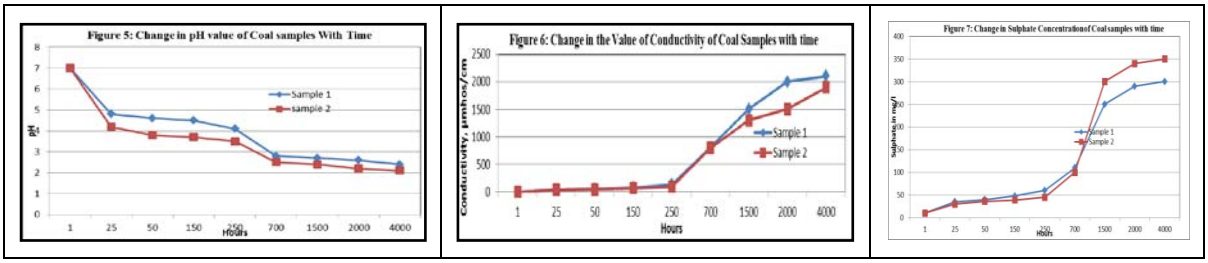

Figure 8-10: Variation in the values of pH, conductivity and sulphate concentration of the two coal samples in distilled water with time

c) Minerology of Coal

Coal sample was subjected to the X-ray diffraction for its mineralogical identification. X-ray diffraction study was done with Match software using ICDD database. The coal sample predominantly showed presence of minerals Pyrite, Nacrite, Muscovite and Kaolinite.

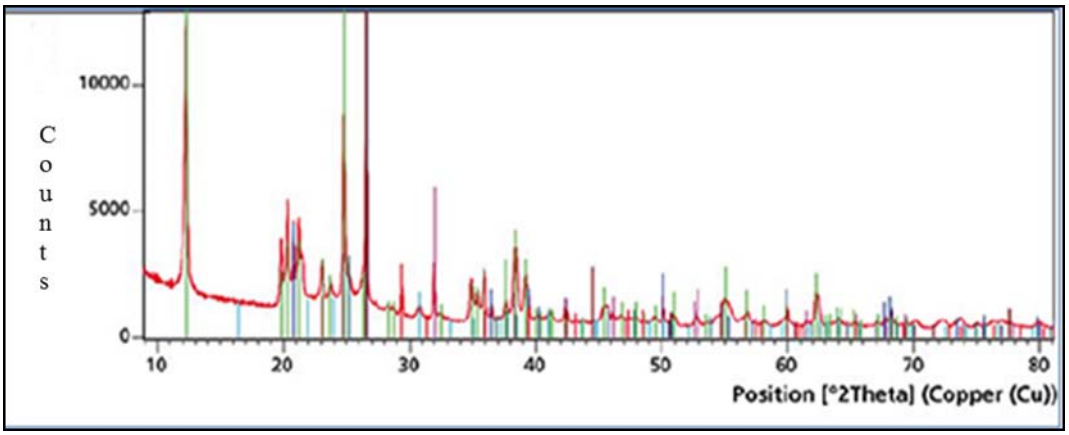

Fig 11: X-Ray Diffractogram of Coal Sample

d) Chemistry of Acid Mine Drainage

Generally the rivers/streams existing in the close proximity to the coal mines/ coal dumping sites in the catchment area are observed having low pH with slightly elevated levels of dissolved metals. The formation of AMD is primarily a function of the geology and hydrology of the area along with the mining technology employed. The amount of iron sulphide in an ore deposit or mine waste plays a crucial role in determining the characteristics of the mine drainage. During the formation of ore deposits, sulphide minerals are formed in the absence of oxygen under reducing conditions. When exposed to atmospheric oxygen or oxygenated waters generating from mining, mineral processing, excavation, or other earthmoving processes, sulphide minerals become unstable and get oxidized.

When pyrite of coal comes in contact with water, a series of complex geo-chemical and microbial reactions occur resulting in the oxidation of pyrite into oxides of iron and sulphuric acid. Formation of sulphuric acid lowers the pH of water. Due to low pH, mobility of metal ions increases and the concentration of dissolved metal ion in water increases which stays dissolved in solution till the pH rises to a level where precipitation of metal occurs. Pyrite weathering and the overall reaction may be summarised as follows:

$$2\ FeS_2 + 7\ O_2 + 2\ H_2O \rightarrow 2\ FeSO_4 + 2\ H_2SO_4$$

$$4\ FeSO_4 + O_2 + 2\ H_2SO_4 \rightarrow 2\ Fe_2\ (SO_4)_3 + 2\ H_2O$$

$$7\ Fe_2\ (SO_4)_3 + FeS_2 + 8\ H_2O \rightarrow 15\ FeSO_4 + 8\ H_2SO_4$$

Once the mining activity is over, these holes and pits are left unattended. During monsoon season these get filled with water. This acid joins the reservoir through various tributaries flowing through this region turning the river water acidic and unfit for consumption.

e) Detrimental Effects of Acidity

Low pH of water is a major cause of deleterious effects on concrete and various hydro mechanical components of the project. It may cause:

- Leaching of lime may occur from concrete
- Loss of concrete strength over a period of time
- Frequent outages in power generation due to corrosion and erosion of hydro mechanical components.

Kopili HE project in particular is suffering due to frequent outrages in power generation due corrosion and erosion of hydro mechanical components. A huge amount of economy and man power is being involved in the process of repair/rehabilitation of all the equipment after every 6-8 months.

f) Steps taken by Authorities

Even after a lot of hue and cry by scientists/engineer/NGOs, media [9, 10] and a ban imposed by the National Green Tribunal (NGT) on unscientific rat-hole mining of coal in Meghalaya, the State Government did not took the matter as seriously as it should be. The performance audit report on the operations of Meghalaya's mining department by the Comptroller and Auditor General of India (CAG) observed: "*There was serious air, water and environmental pollution caused* by *illegal, unregulated and indiscriminate mining being carried on in various parts of the state of Meghalaya*". The report rapped the state government for not taking effective steps to control acid mine drainage as suggested by the pollution control boards. The state pollution control board began investigation in 2011 into the sudden death of fishes in Lukha River in Jaintia Hills district and reported the matter for information and necessary action in 2012. According to CAG the acidic water caused severe corrosion in the machinery of two of NEEPCO projects in 2006-07 causing frequent power outages due to the failure of cooler tubes and cooling water pipes in the power station [11]. In the year 2008-09 major Central agencies and authorities like the Central Water Commission, Central Electricity Authority and Central Soil and Material Research Station Station, after thorough investigation confirmed that acidic water had badly affected the Kopili HE Plant. Of late the Meghalaya government has assured a separate fund for reclaiming all the degraded lands due to coal mining to make them fit for vegetation and farming activities.

Also study has been performed using Cladophora algal which is found in abundance at site, to observe its effect on the improvement of pH of water [12-18]. Though the results seemed very promising, however, algae based methods of abating AMD are not the ultimate solution to the problem and there is room for more studies.

g) Other Environmental Effects due to high acidic nature of River Water

The increased acidity caused by acid mine drainage has a range of negative effects depending on the severity of the pH change. Many river systems and former mine sites are totally inhospitable to aquatic life, with the exception of "extremophile" bacteria. Additionally, heightened acidity reduces the ability of streams to buffer against further chemical changes. In addition to the direct negative effects of increased acidity and the increased release of toxic metals, an additional problem can also be created when the acid reacts with the rock that neutralizes it. As the water becomes less acidic, metals and other solids come out of solution. One of these precipitates, known as "yellow boy," can smother life on the streambed. These streams turn a distinctive orange/red color, as their beds are coated by a solid veneer of chemical precipitate resembling brightly colored chocolate "hard sauce" or paint. (As can be seen in Figure 2 above). High acidity causes ecological harm to downstream areas which adversely affects the economy of the region too. Treatment of acid mine drainage has in many cases proved economically impossible as money can only pay for the material loss but can never repay the health problems associated with acid waters and heavy metal toxicity, loss of biological services from exterminated water organisms, and the loss of recreational and subsistence fishing and hunting opportunities.

IV. Prevention and Mitigation

There are three basic ways to limit acid mine drainage; prevent sulfuric acid from forming, neutralize the acid after it forms, or collect runoff/seepage to contain the acid.

1. To stop the formation of sulfuric acid, the waste rock and tailings from a mine must be prevented from coming in contact with oxygen. Oxygen can come from either the flowing water or air.
2. Strategies for keeping tailings separate from oxygen include submerging the tailings under still water, sealing them behind a synthetic barrier, or burying them underground.
3. Large mines typically isolate acid-generating rock underwater to reduce the rate at which oxygen interacts with the material.

The water flowing out from waste ponds needs to be treated to neutralize acidity before it is released into the environment. Often, however, acid prevention strategies fail. Isolating very large quantities of acid-generating waste and rock is difficult, either above or below ground and in many cases is effectively impossible. Once acid has been generated and toxic metals dissolved into it, the treatment of water is very expensive.

Algae strains such as Spirulina sp., Chlorella, Scenedesmus, Cladophora, Oscillatoria, Anabaena, Phaeodactylum tricornutum have showed the capacity to remove a considerable volume of heavy metals from AMD. They act as "hyper-accumulators" and "hyper-adsorbents" with a high selectivity for different elements. In addition, they generate high alkalinity which is essential for precipitation of heavy metals during treatment. [19]

Lime neutralisation remains by far the most widely applied method. This is largely due to the high efficiency in removing dissolved metals through

neutralisation, combined with the fact that lime costs are low in comparison to alternatives. Lime treatment essentially consists in bringing the pH of the AMD to a point where the metals of concern are insoluble. These metals therefore precipitate to form minuscule particles, but the abundance of iron and sulfate in AMD usually renders it ineffective by forming iron hydroxide and gypsum precipitate coating on the surface of lime. At the same time TDS of water may also go up and create another set of problems for different uses of water.

V. Conclusion

The myopic vision of human has converted the treasure into curse. The rat-burrowing type of mining in very-very unscientific manner is causing the acidification of rivers and streams in the state of Meghalaya. The acidic discharge not only affecting the environment adversely but also severely eroding/corroding the installed hydro-mechanical equipment which leads to frequent outages and increased financial burden as these parts need to be repaired or replace. Though remedial reassures suggested for durable concrete may help the projects to some extent, yet the larger question is the improvement of catchment area and the quality of river water to save the dying rivers. Situation is very-very grim there and even after so tough directions and decisions taken by National Green Tribunal, no concrete result is observed at site yet as the observations made during the recent visit to the project site show that the water is highly acidic with pH as low as 3.65 at some stretches.

In order to resolve the issue of safe drinking water, environment, flora and fauna along with aquatic life, durability of major projects and above all the life of river itself, there is an urgent need for augmenting/ upgrading the catchment area of kopili River. The major step that can be beneficial in the line will be the regulation of mining activities. Due to the complexity of the issues associated with individual project and site, there is no single strategy like "one-size-fits-all", hence according to the need of each site, multifold measures including tackling the menace of AMD and eco-friendly, low cost treatment of catchment area and surface runoffs should be taken of as an immediate measure to find a sustainable solution to the issues. The ecosystem approach should be adopted to manage the environment and its natural re-sources so that economic, social and environmental benefits for a healthier and more resilient nation may be delivered.

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Fingerprints of Total Petroleum Hydrocarbons in the Water and Sediments of Onyima Creek (Ede Onyima), Engenni Ahoada West, Rivers State, Nigeria

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Abstract- Water and sediment samples were collected from Onyima Creek (Ede Onyima) for eight months at intervals of two months to analyze the level of distribution and possible sources of total petroleum hydrocarbons contamination. Petroleum hydrocarbons components were determined by Gas Chromatography-Flame Ionization Detector (GC-FID) and then quantified after necessary extraction procedures and, laboratory pretreatment have been performed. The petroleum hydrocarbons chain length recorded ranged from C_8-C_{40} in both water and sediment columns. The total petroleum hydrocarbons recorded in the water column of the creek ranged from 10.485-24.762mg/L, while in the sediments, recorded value ranged from25.460-69.357mg/Kg. The source identification ratios and indices used include C_{31}/C_{19}, CPI, ACL, C_{15}-C_{19} odd hydrocarbons, C_{18}-C_{22} even hydrocarbons, LHC/SHC, and, L/H showed that the origin of total petroleum hydrocarbons contamination in the creek was from natural and anthropogenic sources. There is, therefore, the need for control and regulation of activities that contributed to the presence of total petroleum hydrocarbons in the creek to safeguard human health and aquatic plants and animals that dwell in the Onyima Creek (Ede Onyima) space.

Keywords: diagnostic indices, onyima creek, molecular markers, monthly variation, sediments, surface water, total petroleum hydrocarbons.

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I. Introduction

THe Onyima Creek(Ede Onyima) was the major transport route between the Engennis in Rivers State and the Ogbias in Bayelsa State before constructing any road that links the two tribes. The creek also served as the main basis of freshwater that the inhabitants depends on. The creek receives its water Source from the Orashi River, which is the parent river that supplies water to the creek. The Engenni axis of the creek is called Ede Onyima. The Engenni axis of the creek in the 1980s and beyond usedto be a fish haven preserved by the Okarki Community in Engenni. Fishes and aquatic reptiles were in abundance in the creek. The creek was treated as a lake where the dwellers were prevented from fishing by laid down laws of the community. This then culminates into a yearly fishing festival known by the Locals as Holiday Ede Onyima. This very day (the holiday), all activities cease, including government work to enable the inhabitants of Okarki to harvest from the abundance of fishes from the creek. The Engenni axis of this creek presently is under pollution threat due to the presence of petroleum hydrocarbons that enter into the creek as a result of illegal oil bunkering and other associated businesses along the creek and its coast.

The presence of petroleum hydrocarbons in water and sediments of aquatic water bodies are either from natural or anthropogenic sources, which are through spillage, transport, effluents from artisanal refineries, accidental discharges, runoffs from farmlands, oil exploration, biogenic (decomposition by organisms) and, seepage from rocks (Al-Imarah *et al.*,2010; Farid *et al.*, 2014). Hydrocarbons of biogenic origin in water environments can also be synthesized by plants, algae, zooplankton, bacteria but the major source of hydrocarbons pollution is derived from human-related activities (Al- Saad, 1995).

Total petroleum hydrocarbons are known to be among hazardous materials because they are potential health risks to man and their carcinogenic nature. Petroleum poses health hazards to man after exposure over a long period and can create discomfort and other health challenges in man (especially those in direct contact). (Azhari *et al.*, 2011). Petroleum hydrocarbons in the aquatic settings float and hinderthe exchange of oxygen and the penetration of sunlight from reaching the lower depth for phytoplankton, and other aquatic plants to make use for photosynthesis, thereby altering the availability of oxygen in the system (Barbooti, 2011). Certain constituents of petroleum hydrocarbons such as normal alkanes, degraded oils, and combusted fossil fuels have low solubility in water (Wattayakorn, 2012) and therefore clog the penetration of oxygen to lower depth of the aquatic environment. The degree of variableness of the oil type and the characteristics of the water that receives the contaminants has a resultant effect on the oil discharged and the degree of pollution that will likely occur (Abel, 2002).

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This research work aimed at the determination of the level of the different total petroleum hydrocarbons components in the water and sediments of the Onyima Creek, and also to classify the leading sources and origin of total petroleum hydrocarbons in the creek to establish a data framework for future evaluation of the creek in terms of total petroleum hydrocarbons contamination.

II. Materials and Methods

This investigation was carried out between the period of December 2019 to June 2020, at intervals of two months on the water and sediments of the Onyima Creek. Several water samples below the surface were collected from the Onyima Creek monthly and mixed. The samples were collected at about 25-30cm below the water surface with glass bottles and were immediately preserved by adding 25 mlcarbontetra chloride (CCl_4), and then transported to the laboratory for pretreatment and chromatographic analysis. The method of UNEP (1989) was adopted to extracting 5L of total petroleum hydrocarbons from the water sample and then mixed with about (25 ml) of CCl_4 for about 20 minutes with the aid of a water mixer. The liquid component was drained out while the petroleum and the remaining (about1L) were then put into an already prepared separator funnel. A mass of5g weight of Na_2SO_4 (anhydrous sodium sulphate) was used to dry the organic phase, which was then collected and put into an already prepared glass column. About 25ml n-hexane was used in dissolving the residue. It was then allowed to pass over a glass column of 20 cm, which was packed with 10g of silica gel of 150 mesh size, glass wool at the bottom, about 5 g weight of deactivated alumina of 150 mesh size and then 5g of Na_2SO_4 (anhydrous sodium sulphate) was added at the top. The total petroleum hydrocarbons components were then eluted with 25ml n-hexane from the glass column. The eluted samples were dried and then stored until the detection of petroleum hydrocarbons components by Gas Chromatography-Flame ionization detector (GC-FID). Helium was used as the carrier gas. The Gas Chromatography-Flame ionization detector was operated at a velocity of 1 ml per minute at a temperature of 280°C and 300°Cfor the injector and detector respectively for the complete separation of the petroleum hydrocarbons components. The column temperature was maintained at 35°C as an initial temperature for 13 minutes then 5°C per minute to a temperature of 280°C (Al-Hejuje *et al*., 2015).

Van Veen Grab was used in collecting the sediment samples at a depth of 50cm of the creek from the top of about 5-6cm into the sediment. Sediment samples collected for total petroleum hydrocarbons were preserved in aluminum containers and thermally insulated with iced-park on the top to prevent rapid evaporation and then transported to the laboratory for further treatment before subjecting the samples to chromatographic analysis. Sediment samples were treated according to the method of Emadi Jamali *et al* (2020).The standard method used was the 3550C EPA (an extraction performed with an ultrasonic device), while the analysis for total petroleum hydrocarbons components, the SW-846 method 8015B, was used. The sediment samples were dried with anhydrous Na_2SO_4 and weighed, and were then ready for extraction. The Surrogate Standards method of 1, 3, Dimethyl-2-nitrobenzene at 250µg/ml in Methyl tert-Butyl Ether) and a solvent mixture of 1:1 dichloromethane/acetone was used. The organic sample extracts were obtained through the use of an ultrasonic machine. The solvent was finally extracted, and then the concentration of the extracted sample was performed and was injected through the vial of the Gas Chromatography-Flame Ionization Detector(GC-FID) (USEPA, 1996).

a) Source Identification and Pollution Markers

Total petroleum hydrocarbons indices used to determine the level of pollution and the origin or sources oftotal petroleum hydrocarbons in the Ede Onyimaenvironment are shown below.

L/ H Ratio: Low Molecular Weight (L) total petroleum hydrocarbons (n-alkanes) originates through marine biogenic sources, while the High Molecular Weight (H) total petroleum hydrocarbons (n-alkanes) are produced through terrestrial vascular plants (Fagbote and Olanipekun, 2013). L is the Summation of the concentrations of the aliphatic hydrocarbon fractions from C_{15} to C_{20} while, H is the Summation of the concentrations of aliphatic hydrocarbon fractions from C_{21} to C_{40}. When the ratio is below 1 signifies contamination from natural sources, and terrestrial biogenic origin and values are above 1then, it indicates natural sources of biogenic origin.

LHC/SHC Ratio: Long Chain Hydrocarbons/ Short Chain Hydrocarbons ratio calculates how abundant phytoplankton and vascular plants are in the creek (Fagbote and Olanipekun, 2013).The summation of C_{15}, C_{17} and C_{19} give SHC while, the summation of C_{27}, C_{29}, and C_{31} gives LHC.

Carbon Preference Index (CPI): This index is the ratio of odd number hydrocarbon fractions to even number hydrocarbon fractions in the sediments. CPI values equal to 1 signifies hydrocarbons that originated from a petrogenic source, while CPI values below 1 are possibly from bitumen and oils that have originated from a pyrogenic (evaporated rocks) source or from a carbonate origin (Fagbote and Olanipekun, 2013).CPI values greater than 1 reveals that the alkanes (total petroleum hydrocarbons) are from biogenic source.

Determination ofC_{31}/C_{19}: This ratio was used in detecting the origin and sources of petroleum hydrocarbons

(n-alkanes) in the marine/aquatic environment. The detection of the presence of C_{31} indicates hydrocarbons of terrestrial biogenic origin, while detection of C_{19} indicates hydrocarbons inputs of marine biogenic sources.

Average Carbon Length (ACL): This index was determined using the mathematical expression of Kiran *et al* (2015) and Wang *et al*. (2015). The index helps evaluate odd hydrocarbons in a molecule present in a sample so that a link will be established with higher plants associated with n-alkanes (petroleum hydrocarbons).

III. Results and Discussion

a) Total petroleum hydrocarbons Concentration in the Surface water of Onyima Creek (Ede Onyima)

The level of surface-water contamination by total petroleum hydrocarbons and the source identification indices used in diagnosing the origin of total petroleum hydrocarbons in Onyima Creek (Ede Onyima) are shown in Table 1. The mean values of the parameters are shown in Figure 1. At the same time, the concentrations of major groups of total petroleum hydrocarbons fractions in the surface water of the creek are illustrated in Figure 2. The level of pollution by total petroleum hydrocarbons within the months investigated lie between 10.485 to 24.762mg/L with a mean concentration of 15.34 6mg/L. The highest value of 24.762mg/L was obtained in June, while the lowest value of 10.485mg/L was obtained in February. The odd number of total petroleum hydrocarbons of C_{15}-C_{19} within the sampled months lie between 1.295 to6.441mg/L with a mean concentration of 3.372mg/L. In contrast, even number of total petroleum hydrocarbons of C_{18}-C_{22} lie within the values of 1.720 to 4.454mg/L with a mean concentration of 4.528mg/L. The observed values for low molecular weight hydrocarbons/high molecular weight hydrocarbons (L/H) lie within the values of 0.698 to 4.207 with a mean concentration value of 1.662 within the months. The C_{31}/C_{19} values observed lie within not detected to 0.003 with a mean ratio of 0.00075. Both C_{31} and C_{19} were observed in December only.

The presence of total petroleum hydrocarbons on the surface water of the Onyima Creek (Ede Onyima) has introduced biochemical changes and geochemical imbalance on the aquatic environment due to the deficiency in oxygen, which was a result of coating of the surface water of the creek. The smothering affects the exchange of gases, the osmo regulation processes, and the life-support system in the creek become threatened, leading to a reduction in the certain species that were present in the creek. This finding was also observed by Luoma *et al* (1997) and Mendelssohn *et al* (2012), who showed that oxygen deficiency in water due to petroleum hydrocarbons floating on the water surface led to losses in the species population and affected the resilience of the community dwellers due to the imposition of hypoxic conditions. The oil has formed sheen on the water's surface due to the discharges of petroleum products by the illegal refiners, and the surface water of the creek has turned brown in coloration, and oil films surround any object that is found floating on the surface of the creek. This observation is similar to that noticed in the Ugbo Water Way by Ashiru and Ogundare (2019).

The activities of illegal oil bunkering, and artisanal oil refining within the area covered by the Onyima Creek (Ede Onyima) has led to the destruction of the ambient ecological system and a gross reduction of fish, aquatic reptiles, and birds within the creek environment as compared to the abundant fish supply by the creek in the 1980s and beyond. This assertion was corroborated by Ezekwe and Utong (2017) in the Oturuba Creek that the manifestation of hydrocarbons on the creek waters has led to the reduction in the quantity of fish catch. Due to the toxic effect of total petroleum hydrocarbons, certain species have been lost. Phytoplanktons and other lower organisms may have been drastically reduced due to the contamination of total petroleum hydrocarbons and tends to affect higher trophic organisms, such as aquatic birds that make use of the creek or river (Langston, 1990). This condition was also observed in Onyima Creek. The total petroleum hydrocarbons in the creek have negatively impacted on aquaculture because of the severity of oil and its tendency to bio accumulate in aquatic organisms like mollusk, fish, mussels, and mammals (Ahmed *et al*., 2014). The livelihood of the communities living along the creek have been affected due to the pollution effect. The activities of oil bunkering and its allied businesses has forestalled the popular "Ede Onyima Holiday" that was always observed in the 1980s and beyond. This was as a reduction in the quality and quantity of fish in the creek and has affected the general life pattern of the people. This assertion was agreed with and corroborated by other authors (Abowei, 1996; ATSDR, 1999).

Table 1: Source Diagnostic Ratios and the Range of Total Petroleum Hydrocarbons in the Surface Water of the Onyima Creek (Ede Onyima) in the Sampled months

Parameters	Months				Range
	December	February	April	June	
TPH	10.650	10.485	15.547	24.762	10.60-24.80
C_{15}-C_{19} (odd number TPH)	3.210	2.540	1.295	6.441	1.30-6.44
C_{18}-C_{22} (even number TPH)	2.170	1.720	4.064	4.454	1.70-4.50
C_{25} – C_{35}	1.205	2.853	6.419	7.634	1.21-7.63
L/H (C_{15}-C_{20}/C_{21}-C_{40})	4.207	0.845	0.698	0.897	0.70-4.21
C_{31}/C_{19}	0.003	-	-	-	nd-0.003

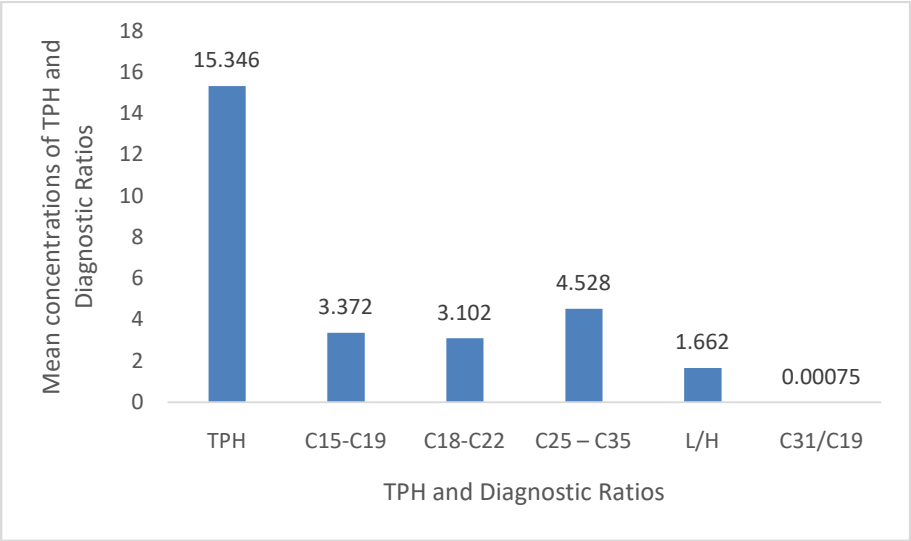

Figure 1: Mean Concentrations of Total Petroleum Hydrocarbons and Diagnostic Ratios in the Surface Water of Onyima Creek (Ede Onyima) in the sampled months

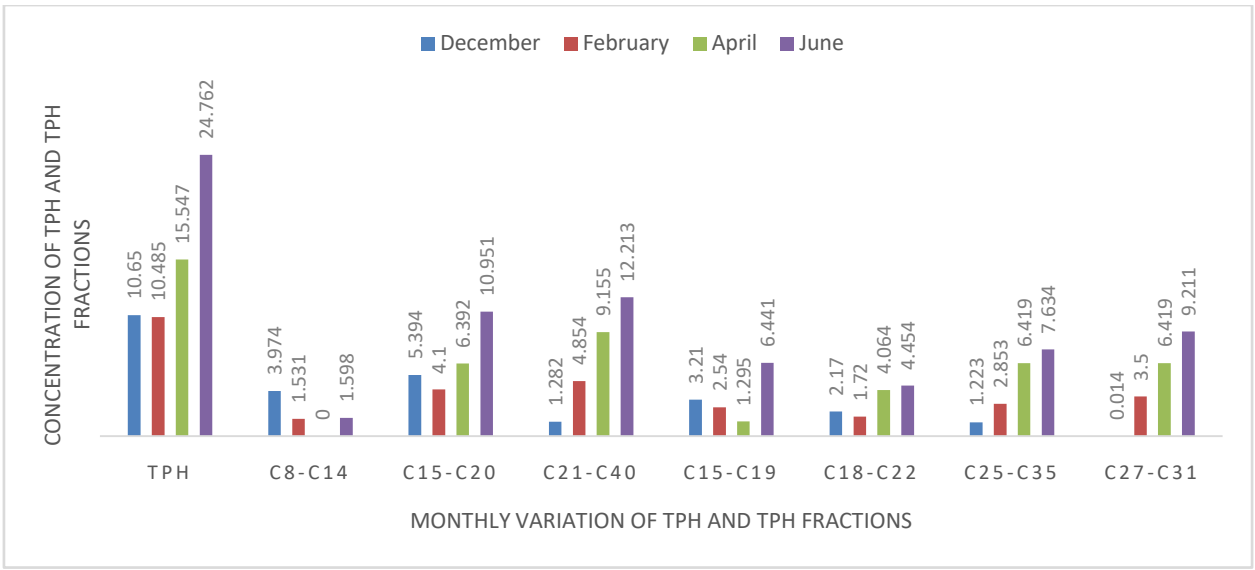

Figure 2: Variation in the Concentration of TPH and TPH Associated Fractions in the Surface water of Onyima Creek (Ede Onyima) in the sampled months

b) Total Petroleum Hydrocarbons Concentration in the Sediments of Onyima Creek (Ede Onyima)

The level of contamination of the sediments ofOnyima Creek by total petroleum hydrocarbons and the indices used in the diagnosis of the source of origin of pollution are shown in Table 2. The mean values for total petroleum hydrocarbons and the source identification indices are illustrated in Figure 3.In contrast the concentrations of major groups of total petroleum hydrocarbons fractions in the sediments of

the creek are illustrated in Figure 4. The total petroleum hydrocarbons concentrations lie between 25.460-69.357mg/Kg with an average concentration of 41.241mg/Kg within the months investigated. The lowest value was obtained in February, while the highest value was obtained in December. Concentrations of 4.509 to 13.623mg/Kg were recorded for C_{15}-C_{19} (odd number TPH) with an average value of 9.223mg/Kg, while 4.094 to 9.365mg/Kg were recorded as the concentrations of C_{18}-C_{22} (even number TPH) with an average value of 6.358mg/Kg. The values obtained for C_{25}-C_{35} total petroleum hydrocarbon fractions lie between not detected to 21.867mg/Kg with an average value of 10.644mg/Kg. The ratio of low molecular weight hydrocarbons to that of high molecular weight hydrocarbons (L/H) lie within 0.601 to 3.518 with an average value of 1.604. The ratio of long chain hydrocarbons to short chain hydrocarbons (LHC/SHC) lies between not detected to 0.719 with an average of 0.180 within the months investigated. C_{31}/C_{19} ratio lies within not detected to 0.020 with an average of 0.005, CPI values were within not detected to 1.481with an average of 0.370 and ACL values lies within not detected to 31.095 with an average of 7.774 within the months. The results also indicated that C_{31}/C_{19}, CPI and ACL values were recorded in the month of December only in the sediments of the creek.

The sediment acts as the natural sink in the marine environment. The constant accumulation of pollutants such as total petroleum hydrocarbons can result in geochemical and biological alterations in aquatic organisms that dwell and feed on the bottom of the creek. The effect of such accumulation gives rise to a reduction in the population of fish, growth of organisms, the diversity of species, and also impair the reproduction of the aquatic organisms. The effect goes further to affect the moisture content, pH, organic carbon and organic matter, and electrical conductivities of the sediments (Singare *et al*., 2011; Onojake and Osuji, 2012). The effect of oil has direct consequences on the habitat of organisms, which results in bioaccumulation, loss of predators, and the migration of aquatic organisms. This resulted from accumulation of hydrocarbons adsorbed in the bottom sediments (Benson *et al*., 2008; Meador *et al*., 1995; Macauley and Rees, 2014).

The sediment absorbs and adsorbs pollutants in the water column. At the critical level of contamination of the sediment through the absorption and adsorption processes, the ecological system of the river/creek changes due to the loss of species and alteration in the ecological diversities of the aquatic system (Markovic, 2003). The food chain at both the bottom and upper levels in the ecological set-up becomes affected (Burton, 2002). There is also the possibility of direct effect on the bottom-feeding organisms, which can easily transfer to the man that consumes the fish and reptiles of the polluted river/creek. The contamination of the creek environment has led to deterioration and degradation of the environment whereby many plants and animals that were originally in the creek are found no more due to possible migration or extinction. This might have arisen due to the blocking of oxygen from properly dissolving into the water and sediment columns of the creek. The observation here is similar to those of Udoh and Akpan (2010) and Ogeleka *et al*., (2016), who observed that oil spill at sea poses a threat to organisms inhabiting the sea.

In general, the effect hydrocarbons contamination of the creek has led to socio-economic problems, such that those that depended on the creek for daily survival and sustenance are now forced to look somewhere else for alternative means of life. The cultural heritage of the people has been lost. The annual fishing event of 'Holiday Ede Onyima' is now foregone and will only remain in the minds of those that saw the festivals. The water of the creek is no more fit for human consumption. The observation above corroborates other authors who agreed that pollution in the environment leads to deterioration and degradation of the environment, creates economic and social challenges and, also loss of cultural heritage, especially in Nigeria, Niger Delta Region (Kponee *et al*., 2005; Ite and Ibok, 2013), where oil is in abundance and environmental concerns are not a priority of the government, and the people.

Table 2: Source Diagnostic Ratios and the Range of Total Petroleum Hydrocarbons in the Sediments of the OnyimaCreek (Ede Onyima) in the Sampled months

Parameters	Months				Range
	December	February	April	June	
TPH	69.357	25.460	36.658	33.489	25.50-69.40
C_{15}-C_{19} (odd number TPH)	13.623	7.558	11.203	4.509	4.51-13.60
C_{18}-C_{22} (even numberTPH)	5.322	6.649	4.094	9.365	4.10-9.40
C_{25} – C_{35}	21.867	-	8.514	12.196	nd-21.90
LHC/SHC	0. 719	-	-	-	nd-0.72
L/H (C_{15}-C_{20}/C_{21}-C_{40})	0.601	3.518	1.340	0.958	0.60-3.52
C_{31}/C_{19}	0.020	-	-	-	nd-0.02
CPI	1.481	-	-	-	nd-1.50
ACL	31.095	-	-	-	nd-31.10

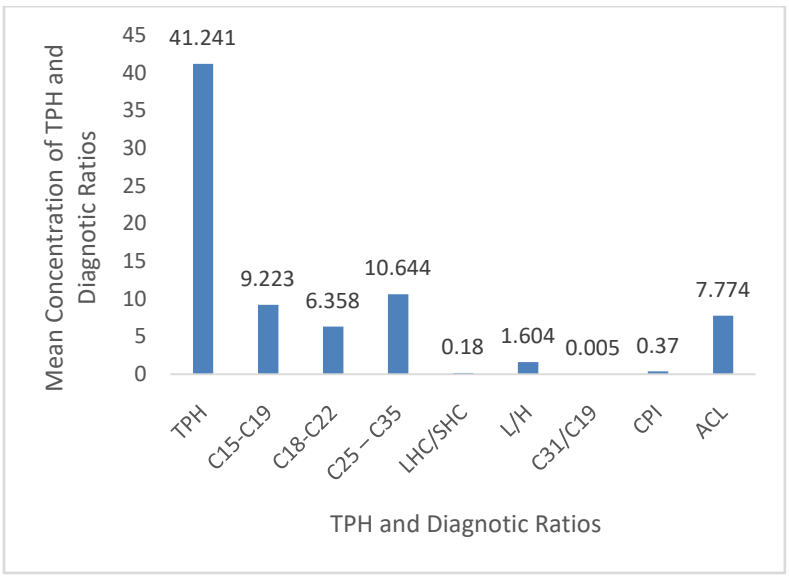

Figure 3: Mean Concentrations of Total Petroleum Hydrocarbons and Diagnostic Ratios in the Sediments of Onyima Creek (Ede Onyima) in the sampled months

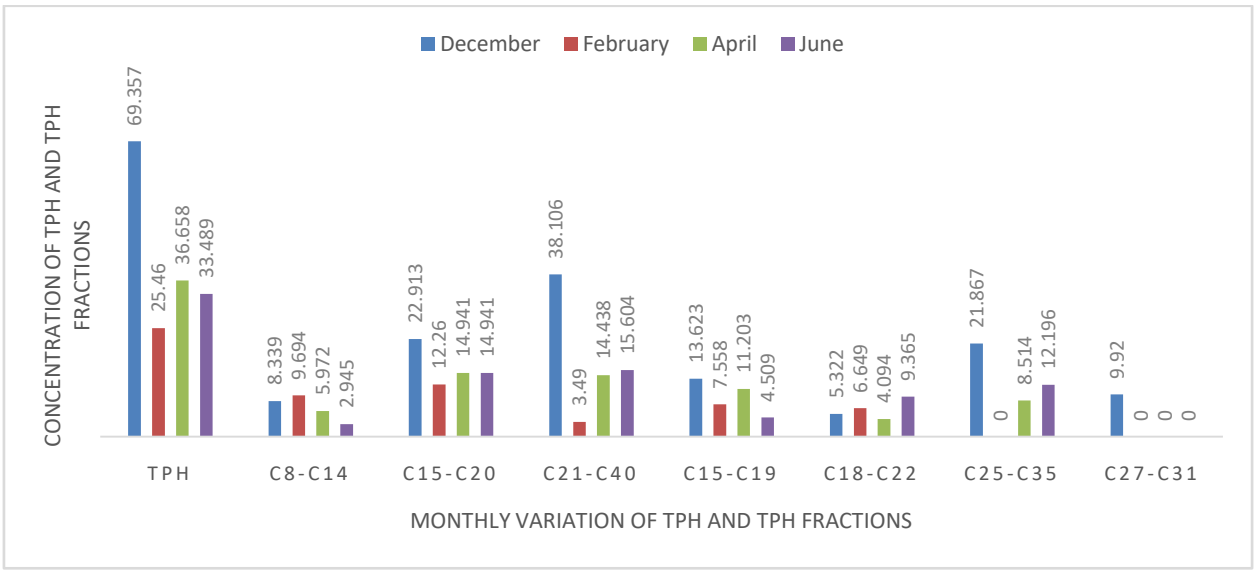

Figure 4: Variation in the Concentration of TPH and TPH Associated Fractions in the Sediments of Onyima Creek (Ede Onyima) in the sampled months

c) *Fingerprints of Total Petroleum Hydrocarbons in the Surface Water and Sediments of Onyima Creek (Ede Onyima)*

The evaluation of the status of total petroleum hydrocarbons in the surface water and sediments of Onyima Creek by using certain indices in identifying and fingerprinting the source of pollution are discussed by applying the method of Adeniji *et al*. (2019a and b). These indices are useful markers and are essential tools in identifying the source of pollution in aquatic environments (Sakari *et al*., 2012).

d) *The Pattern of Total Petroleum Hydrocarbons Distribution in the Onyima Creek (Ede Onyima).*

The appearance of hydrocarbons on the surface water and sediments of the Onyima Creek was through the activities of man, the geochemical process of seepage, and hydrocarbons production through the activities of living organisms in the environment. The biosynthetic nature of living organisms that occupy the aquatic environment under certain conditions produces trace amounts of n-alkanes or petroleum hydrocarbons, while a great quantity of total petroleum hydrocarbons in aquatic surroundings resulted from activities of man (Sakari *et al*., 2012).

The variation of total petroleum hydrocarbons fractions in the surface water and sediments of Onyima Creek was an indication that different sources were responsible for petroleum hydrocarbons found in the creek. The C_{25}-C_{35} fractions had an average concentration of 4.528mg/L in the surface water and 10.644mg/Kg in the sediments, which was an indicated biogenic input from vascular and terrestrial plants. The results showed a slight dominance of C_{15}-C_{19} hydrocarbon fractions against the C_{18}-C_{22} hydrocarbons fractions in both water and sediment columns, which attests to inputs from algae and phytoplankton sources of biogenic origin. The presence of C_{16}, $C_{18,}$ and C_{20} fractions in both surface water and sediments was an indication of an anthropogenic source of pollution in the creek. The presence of the C_{12} and C_{14} components in the creek suggested inputs from microbial biogenic activities and origin (Gao and Chen, 2008; Al-Baldawi *et al*., 2015).

The study revealed that total petroleum hydrocarbon fractions of C_8, C_{14}, C_{15}-C_{39} were present in the surface water and sediments of the Onyima Creek (Ede Onyima). However, the C_{32}-C_{40} fractions were either in little quantity or absent in certain months of the study. Heavier hydrocarbon fractions were dominant over the lighter hydrocarbon fractions. Odd hydrocarbon fractions of C21, and above were in little quantity or absent from the water and sediment columns of the creek. This observation disagreed with the findings of Ahmed *et al*. (2015). The presence of aliphatic hydrocarbons in the creek originated completely from biogenic sources. The presence of total petroleum hydrocarbons (n-alkanes) in the surface water and sediments of the creek was of the biogenic and anthropogenic origin. The presence of total petroleum hydrocarbon fractions in the creek may be due to runoffs from self-sustaining refining sites and farmlands during rain and direct discharge of contaminants by the operators of unauthorized refineries prevalent in the area of study (Edori *et al*., 2020).

e) *Low Molecular Weight Petroleum Hydrocarbons/High Molecular Weight Hydrocarbons (L/H)*

This ratio varied from0.698 to 4.207 in the months considered with an average of 1.662 in the surface water and the sediments; it varied from 0.601 to 3.518 with an average of 1.604 within the months under investigation. When the ratio is less than one, it shows a clear picture of the dominance of petroleum hydrocarbons from marine animals, higher plants, and aquatic bacteria. Still, values close to one is an indication of total petroleum hydrocarbons from plankton and petroleum origin. Still, when the ratio is more than two, it is pollution from fresh hydrocarbon oil in the aquatic environment (Zrafi *et al*., 2013). The results from the table indicated that there was the presence of fresh oil in the creek, which was as a result of direct discharge from artisanal or self-sustaining refining sites abundant in the region and also from contamination due to planktons aquatic bacteria, marine animals, and higher plants.

f) *Long Chain Hydrocarbons/Short Chain Hydrocarbons (LHC/SHC)*

Short-chain hydrocarbons originate from plankton, and benthic algae, while long-chain hydrocarbons usually originate from vascular plants. Still when the ratio falls within 0.21 to 0.80, it shows that phytoplankton is dominating and when it falls within 2.38 to 4.33, it is a mixed origin, but when the ratio is greater than four, the origin is terrestrial plant waxes (Bianchi, 2007). The value of the ratio recorded in this work fell between not detected to 0.719 with a mean value of 0.180, which indicates that the origin was from phytoplankton.

g) *Determination of C_{31}/C_{19} Ratio*

This ratio is used to quantify the predominance of hydrocarbons of terrestrial biogenic origin against inputs from marine biogenic sources (Fagbote and Olanipekun, 2013). The C_{31}/C_{19} hydrocarbon ratio was recorded only in December in the surface water of the creek with a value of 0.003, and that of the sediments was 0.0198. The ratio was only calculated in this month due to the non-detection of the C_{31} fraction in the other months investigated. This shows a predominance of the C_{19} fraction against the C_{31} fraction in the area of study. This showed that total petroleum hydrocarbons present in the creek were from marine biogenic sources. Values of the ratio higher than 0.4 reveal that hydrocarbons

present are of non-marine origin (Ahmed *et al*., 2015). The value obtained in Onyima Creek (Ede Onyima) surface water and sediments were all less than 0.4 which signified little presence of hydrocarbons of terrestrial origin and more of marine biogenic sources.

h) The Carbon Preference Index (CPI)

This index in the sediment is expressed mathematically as;

$$CPI = 0.5\ [(C_{25}\text{-}C_{33})/(C_{25}\text{-}C_{32})] + [(C_{25}\text{-}C_{33})/(C_{26}\text{-}C_{34})]$$

The ratio can give the knowledge of the dominance of naturally occurring hydrocarbons as against anthropogenic hydrocarbons (Wu *et al*., 2001; Maioli *et al*., 2011). The CPI value ranged between not detected to 1.481, with an average of 0.370 obtained in the Onyima Creek (Ede Onyima). The finding showed that aliphatic hydrocarbons probably originated from natural sources. When CPI value is greater than one (in the range between 3 and 10), it identifies that the total petroleum hydrocarbons present is from biogenic sources (e.g., waxes of terrestrial vascular plants, and algae) and majorly predominated by odd-numbered total petroleum hydrocarbons. When there is odd-numbered hydrocarbon concentrations of C_{15}-C_{21}, the source is mostly from algae or microbial origin and the concentration range originating from C_{23}-C_{31} is majorly from vascular plants. The presence of total petroleum hydrocarbons from petrochemical source have CPI values close to 1 (Luan and Szelewski, 2008; Michelle *et al*., 2014).

(Average Carbon Length ACL)

The mathematical expression used in calculating ACL is given as;

$$ACL_{value} = 25(nC_{25}) + 27(nC_{27}) + 29(nC_{29}) + 31(nC_{31}) + 33(nC_{33})\ C_{25} + C_{27} + C_{29} + C_{31} + C_{33}$$

In non-polluted sites, the value is always constant and fluctuates in value in sites polluted with total petroleum hydrocarbons (Jeng, 2006). The ACL value in the sediments of the Onyima Creek (Ede Onyima) was an indication that total petroleum hydrocarbons were from both natural and anthropogenic sources.

IV. Conclusion

The total petroleum hydrocarbons inOnyima Creek (Ede Onyima) was within the range or slightly higher than the acceptable limit of pollution in the surface water and slightly higher or lower than the limit in the sediments during the months considered for investigation. The contamination range showed not polluted to slightly polluted by total petroleum hydrocarbons in both surface water and sediments of the creek. The creek's status was also provided by the fingerprinting of the surface water and the sediments, which have provided basic data for developing measures in controlling the pollution of the creek due to oil and other related activities within the area. The total petroleum hydrocarbons in the area originated from both anthropogenic and natural sources. This was revealed through the application of diagnostic ratios, which are relevant biomarkers in hydrocarbons analysis. A proper monitoring system should therefore be established to effectively monitor the creek and to continuously sensitize the individuals involved in the oil business so that the pollution of the aquatic environment of the creek will be minimized.

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Comparative Analysis of Quality of Sources of Drinking Water used by Scavengers in Gosa Area of FCT-Abuja, Nigeria

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Abstract- The study assessed the quality of sources of drinking water used by scavengers in Gosa Area of the FCT. The study adopted the experimental research design. The study adopted the purposive sampling technique. Similarly, Sample used in the study were three sources of drinking water in the study area, namely from boreholes and shallow wells. Water samples collected was prevented from being exposed to sunlight. Samples were packed in plastic cooler containing ice for preservation and analysed within 24hours from the time of sample collection to avoid errors that may be introduced due to environmental factors. The samples collected were comparatively analyzed based on their physical and chemical properties, within the premise of drinking water quality as approved by the Standard Organisation of Nigeria (SON), the National Agency for Food, Drug Administrative Control (NAFDACT). The results of the study revealed that all the sampled water sourced in the study were odourless and in line with the requirement of NAFDAC and SON.

Keywords: *comparative, water, quality, scavengers, used.*

GJSFR-H Classification: *FOR Code: 059999p*

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Iliyasu M. Anzaku [α] & Garba Umar [σ]

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Keywords: comparative, water, quality, scavengers, used.

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I. Introduction

Water is vital to the existence of all living organisms, but this valued resource is increasing being threatened as human populations grow and demand for more water of high quality for drinking purposes and economic activities increases. The Greek philosopher Pindar described water as the "best of all things". Indeed, nothing could be further from this view is not surprising since the need for water, throughout human history, has always been appreciated. Water is present everywhere without which life will simply cease to exist. It is constantly in motion, passing from one state to another and from one location to another. Irrespective of its movement as rivers or streams or stationary as it is in lakes, it invariably contains extraneous materials, due to natural causes and human activities (Biswas, 2008). Almost all of the planet's water (97%) occurs as salt water in the oceans (Bouwer, 1978). Of the remaining 3%, two-thirds occur as snow and ice in polar and mountainous regions, and only about 1% of the global water as freshwater (Bouwer, 2000).

Generally, water is obtained from two principal natural sources; Surface water such as fresh water lakes, rivers, streams, and Ground water such as borehole water and well water (McMurry & Fay, 2004; Mendie, 2005). It is a chemical substance with the chemical formula H_2O. Its molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is a liquid at ambient conditions, but it often co-exists on Earth with its solid, ice, and gaseous state. Groundwater is subsurface water that fills voids and permeable geological formations. It accounts for about 97% (excluding permanently frozen water) of the Earth's useable freshwater resource (Canter *et al.*. 1987).

Groundwater does not exist in isolation, but is an integral component of the hydrological cycle: the endless circulation of water between oceans, atmosphere and land. Groundwater aquifers are periodically replenished by precipitation and by surface water percolating down through the soils. Water stored in aquifers is usually in motion, flowing slowly under the influence uf gravity, until it discharges into a spring, stream, lake, wetland or the ocean or is taken up by plants or is extracted by wells. Hydrologic studies on the

water mass balance are usually conducted within a watershed, since the earth's water cycle is too large to be studied easily. The physical hydrologic processes of precipitation, infiltration, surface runoff, subsurface flow and stream flow play an important role in the propagations of contaminants generated by human activities in a particular watershed. However, depending on the particular climatic, geologic, topographic and vegetative characteristics of the watershed in question, some of these processes might be negligible (Sergio. 1997).

In many developing countries over the years, ground water remains one of the dependable sources of usable water in fast growing towns and villages where the supply of potable water is not consistent. Water abstraction for drinking use agricultural production, mining, industrial introduction power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem, but also the availability of safe water for human consumption. Due to vast anthropogenic activities, water quality is being lost causing extremely bad health problems to consumers of it as well as deteriorating the quality of soil, plants and other living organism that depends on water (WHO, 2002).This research examined the physicochemical as well as biological characteristics of drinking water in Gosa.

II. Materials and Methods

a) *Research Design*

Because a research design is a time-based plan that guides the selection of sources and types of information all based on the research questions (Cooper & Schindler, 2014), the most suitable research design for a study is one that minimizes bias, maximizes the reliability of data collected and in line with the purpose of the study. Hence, this study adopted the experimental research design.

b) *The Study Area*

The land of Abuja was the south-western part of the ancient kingdom of Zazzau (Zaria). The name “Abuja” was derived from Abu Ja, a brother to Muhammadu Makau, the Hausa ruler of Zaria. Makau had left Zaria after being defeated by the Fulani people and settled in the area now known as Abuja. The study area, Abuja, the Federal Capital Territory of Nigeria is situated within the geographic coordinates of Latitude: 09 10′ 00″ N and Longitude: 007 11′ 00″ E (UKEssays, 2016). The area is centrally located and had few existing residents, as such it was chosen to be the Federal Capital Territory. Plans for Abuja were first announced by decree in 1976. Most of the construction for city began in the 1980's. Today, it is Africa's only purpose-built capital city. Abuja became the capital city of Nigeria since December 12th 1991, when it replaced the previous capital Lagos. However, Abuja was planned and mainly built in the 1980s.The Federal Capital Territory is bordered by four states. Kaduna to the north, Kogi to the south, Nasarawa to the east and Niger to the west. For administrative purposes the FCT is divided into six area councils namely; Abaji, Abuja Municipal, Gwagwalada, Kuje, Bwari and Kwali Area Councils. Within the Area Councils there are locations designated as Satellite Towns, which receive priority attention with regards to infrastructural development. For the purpose of Infrastructural development, the Satellite Towns are under the Department of Satellite Towns Infrastructure (DSTI) of the Federal Capital Development Authority (FCDA).

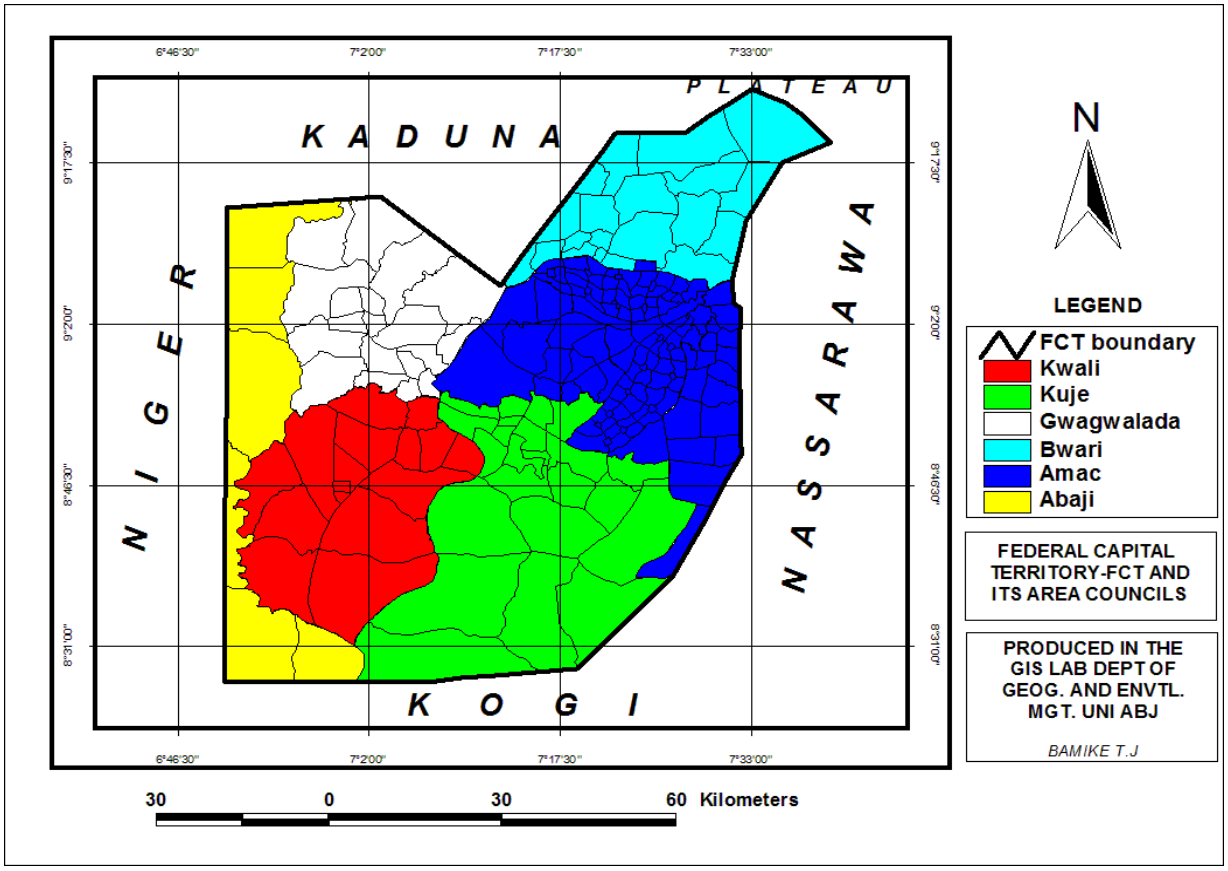


Figure 1: Map of Abuja highlighting all six Area Councils

c) Field Work

The filed exercise shall include the followings;

d) Water Samples

3 sample points were used (location of the water sources namely well, borehole and estate borehole). A total of 3 sample of water were collected from each of the water sources (well, borehole and estate borehole) in the Gosa dumpsite, making a total of 3 water samples. These were collected weekly over a period of 1 month. The essence of this is to ensure quality control during the analysis of chloride and nitrate i.e. test for other parameters except nitrate will be done from sample containers that is treated with HNOs while test for all other parameters except chloride will be done from sample containers that is treated with Hcl.

e) Sampling Technique

The sampling technique employed in the study by the research was the purposive sampling technique.

f) Sample Collected

For water sample from boreholes & shallow wells, GPS positions were given of the site where samples were collected. Water samples were collected from the study area in clean 2litres plastic jar with screw caps. The bottles were labelled using appropriate codes. Samples were collected from the study area in July, 2019.

g) Sample Storage

Water samples collected was prevented from being exposed to sunlight. Samples were packed in plastic cooler containing ice for preservation and analysed within 24hours from the time of sample collection to avoid errors that may be introduced due to environmental factors (Todd & Mays, 2005). The laboratory analysis was carried out at Abuja Environmental Protection Board (AEPB) Laboratory, located in WUPA Waste Treatment Plan in Idu.

III. Results and Discussion

Table 1: Results of Parameters of Sampled Source of Drinking Water in the Study Area

S/No.	PARAMETERS	RESULTS			Nigeria Drinking Water Limits *(NAFDAC & SON)*
		Sample 1*: Well*	Sample 2: *Public Borehole*	Sample 3: *Estate Bore Hole*	
1	Odour	Odourless	Odourless	Odourless	Odourless
2	Taste	Taste	Taste	Taste	Tasteless
3	Colour	Colourless	Colourless	Colourless	Colourless
4	Ph	5.00	6.69	6.53	6.5-8.5
5	Temperature *(°c)*	26.1	26.4	26.4	31
5	Conductivity *(µS/cm)*	119.2	112.7	103	100
7	Turbidity*(NTU)*	13.8	1.3	1.3	5
8	T. Hardness (*mg$CaCo_3$/l*)	82	105	85	100
9	Total Dissolved Solid *(TDS mg/l)*	60.6	50.7	50.3	500
10	Total Suspended Solids *(TSS mg/l)*	14.0	2.0	2.0	10
11	Chloride (*mg/l*)	45.0	23.5	19.9	250
12	Sulphate (*mg/l*)	35.7	29.0	26.7	250
13	Dissolved Oxygen (*mg/l*)	6.9	7.1	6.8	250
14	BOD (*mg/l*)	6.9	7.1	6.8	No standard
15	COD (*mg/l*)	13.5	8.0	7.8	< 10
16	T. Coliform (CFU/100mL)	100	200	10	< 10
17	E. coli (CFU/100mL)	10	3	0	Nil
18	Salmonella (CFU/100mL)	2	2	0	Nil

Source: Lab analysis of result of raw water sample from the study area (WUPA WWTP Laboratory), 2019.

The data presented in Table 1 depicts the parameters of water quality (with respect to the scope of the study) from the sampled source of water in the study area, laboratory results on the concentration of these parameters of fresh water from the sampled sources water in the study area, as well as the acceptable limit of drinking water in Nigeria as approved by National Agency for Food and Drug Administration and Control (NAFDAC) and Standard Organisation of Nigeria (SON). The data presented in Table 2 represents the concentration of physical parameters of water quality in the study area.

Table 2: Concentration of Physical Parameters of Water Quality in the Study Area

S/No.	PARAMETER	RESULTS			Nigeria Drinking Water Limits *(NAFDAC & SON)*
		Sample 1: *Well*	Sample 2: *Public Bore Hole*	Sample 3*: Estate Bore Hole*	
1	Odour	Odourless	Odourless	Odourless	Odourless
2	Taste	Taste	Taste	Taste	Tasteless
3	Colour	Colourless	Colourless	Colourless	Colourless
4	Temperature *(°C)*	26.1	26.4	26.4	31
5	Turbidity*(NTU)*	13.8	1.3	1.3	5

Source: Laboratory analysis, 2019.

a) Odour and Taste

Taste and odour are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salty (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However, sweet and bitter tastes are produced by more complex organic compounds. Odour is produced by gas production due to the decomposition of organic matter or by substances added to the wastewater. Odour is measured by special instruments such as the Portable H2S meter which is used for measuring the concentration of hydrogen sulfide. The result depicted in Table 2 shows that all the sampled water sourced in the

study were odourless and in line with the requirement of NAFDAC and SON. With respect to taste, all the sampled water sources in the study area had test, which is against NAFDAC and SON guideline for safe drinking water.

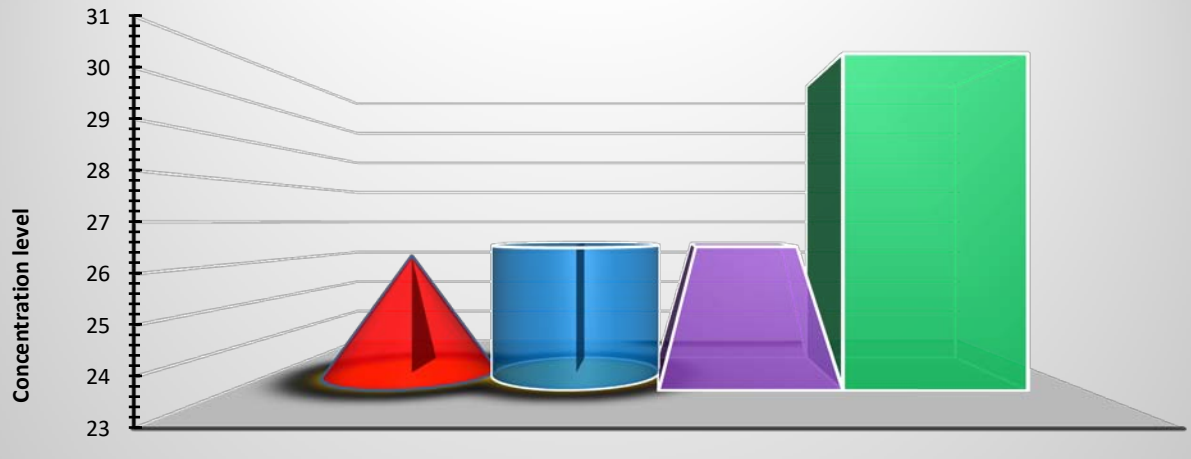
b) Colour

Colour in water is primarily a concern of water quality for aesthetic reason. Coloured water gives the appearance of being unfit to drink, even though the water may be perfectly safe for public use. Colour of the water body can indicate the presence of organic substances, such as algae or humic compounds. In recent times, colour has been used as a quantitative assessment of the presence of potentially hazardous or toxic organic materials in water. Colour is vital as most water users, be it drinking or industrial, usually prefer colourless water. The result presented in Table 4.2 shows that all the sampled sources of water in the study area were colourless and within NAFDAC and SON safety guideline for safe quality of drinking water.

c) Temperature (°C)

Temperature is a measure of the average energy (kinetic) of water molecules. It is measured on a linear scale of degrees Celsius or degrees Fahrenheit. Temperature is a basic water quality variable. It determines the suitability of water for various forms of aquatic life. Depending on the geographic location the mean annual temperature varies in the range of 10 to 21°C with an average of 16°C. Temperature affects a number of water quality parameters such as dissolved oxygen which is a chemical characteristic. Oxygen solubility is less in warm water than cold water. Temperature also affects the aquatic life, for example, trout and salmon require cool temperature for survival and reproduction whereas bass and sunfish do better at warmer temperatures. Temperature in water bodies generally follows mean daily air temperature. It influences: amount of oxygen that can be dissolved in water, rate of photosynthesis by algae and other aquatic plants, metabolic rates of organisms, sensitivity of organisms to toxic wastes, parasites and diseases, and timing of reproduction, migration, and aestivation of aquatic organisms. The above results depicted in Table 2 reveals the temperature of the various sample sources of water in the study area. From the result revealed an average temperature of 26.1°C and 26.4°C, all which fall within the approved 31°C of NAFDAC and SON safety guideline for quality drinking water.

Figure 1: Concentration of Temperature



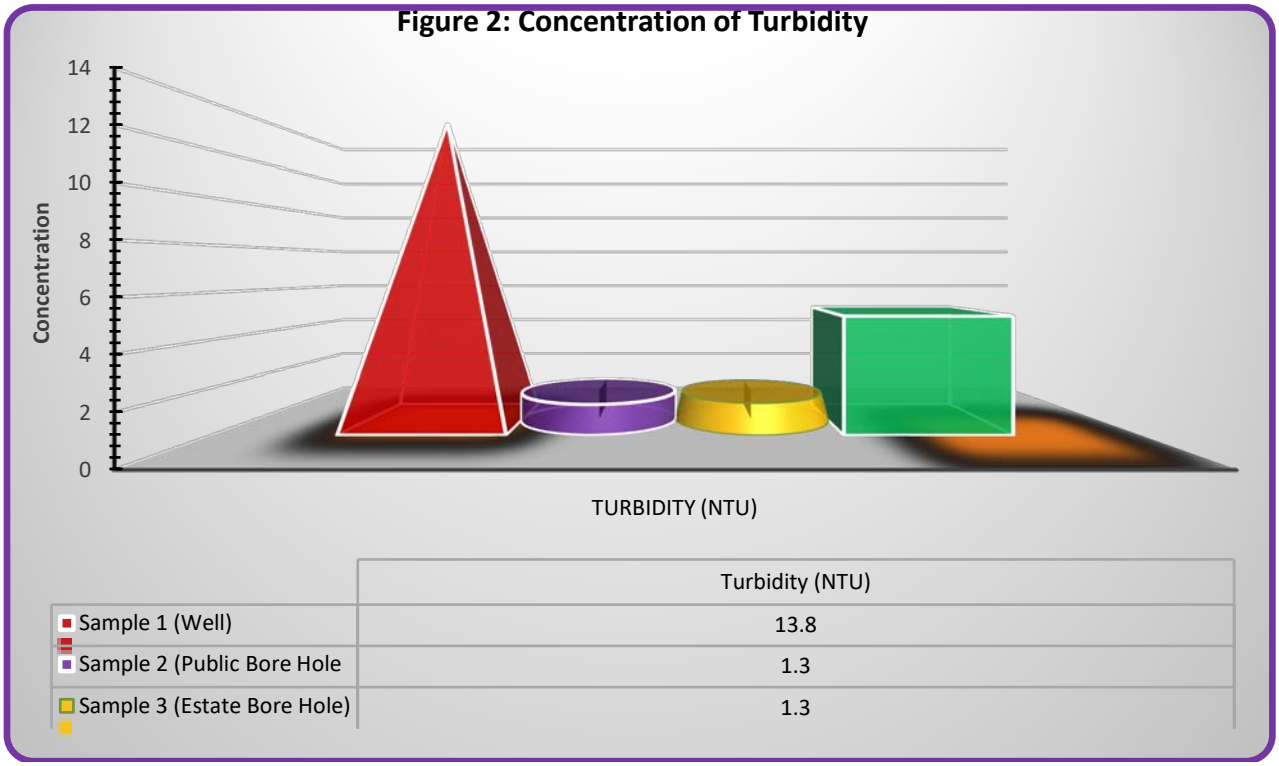
	Temperature
Sample 1 (Well)	26.1
Sample 2 (Public Bore Hole)	26.4

Source: Author's computation, 2019.

d) Turbidity (NTU)

Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons. Transparency of natural water bodies is affected by human activity, decaying plant matter, algal blooms, suspended sediments, and plant nutrients. Turbidity provides an inexpensive estimate of total suspended solids (TSS) concentration. It has little meaning except in relatively clear waters but is useful in defining drinking-water quality in water treatment.

From Table 2, only two out of the 3 sampled sources, namely 2 (Borehole) and 3(estate borehole) had their levels of turbidity within the limit of acceptable standard of drinking water of NAFDAC and SON of 5. The levels of turbidity were 1.3 respectively for both sources. The highest level was obtained from 1(well) with a turbidity level of 13.8.



Source: Author's computation, 2019.

e) *The Concentrations of Chemical Parameters of Water Quality in the Study Area*

The data presented in Table 3 represents the concentration of physical parameters of sampled water quality in the study area, measured and compared against the allowable limit by NAFDAC, SON, and WHO for drinking water quality.

Table 3: Concentration of Chemical Parameters of Water Quality in the Study Area

S/No.	Parameter	Results			Nigeria Drinking Water Limits (NAFDAC & SON)
		Sample 1: Well	Sample 2: Public Bore Hole	Sample 3: Estate Bore Hole	
1	pH	5.00	6.69	6.53	6.5-8.5
2	Conductivity (μS/cm)	119.2	112.7	103	100
3	Total. Hardness (*mg*$CaCo_3$/*l*)	82	105	85	100
4	Total Dissolved Solid (*mg/l*)	60.6	50.7	50.3	500
5	Total Suspended Solid (*mg/l*)	14.0	2.0	2.0	10
6	Chloride (*mg/l*)	45.0	23.5	19.9	250
7	Sulphate (*mg/l*)	35.7	29.0	26.7	250
8	Dissolved Oxygen (DO *mg/l*)	6.9	7.1	6.8	250
9	Biological Oxygen Demand(BOD*mg/l*)	6.9	7.1	6.8	No standard
10	Chemical Oxygen Demand (CO*mg/l*)	13.5	8.0	7.8	< 10

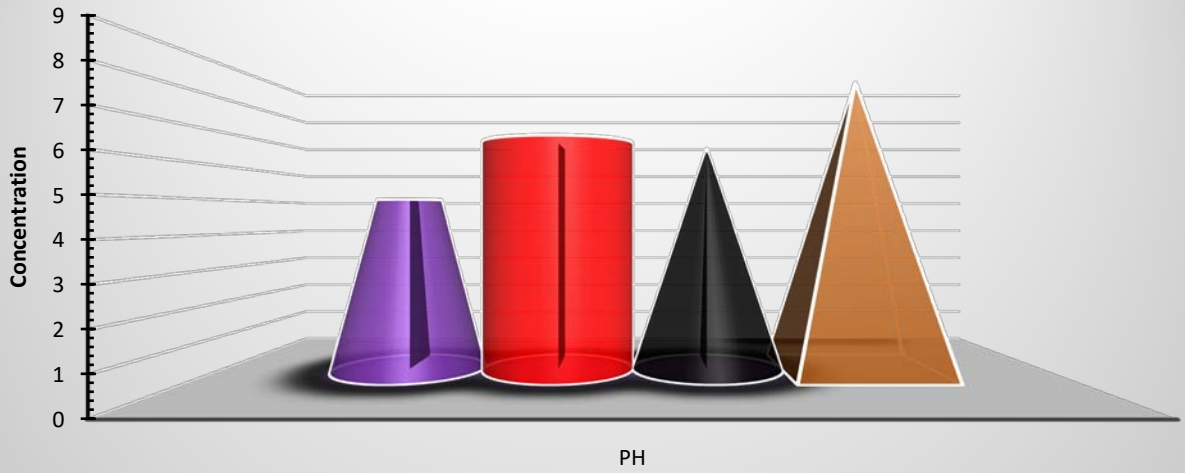
Source: Laboratory analysis, 2019.

f) *pH*

pH is classed as one of the most important water quality parameters, as it measures how acidic or basic (alkaline) water is. It is defined as the negative log of the hydrogen ion concentration. The pH scale is logarithmic and ranges from 0 (very acidic) to 14 (very alkaline). For each whole number increase (i.e. 1 to 2) the hydrogen ion concentration decreases tenfold and

the water becomes less acidic. The range of natural pH in fresh waters extends from around 4.5, for acid, peaty upland waters, to over 10.0 in waters where there is intense photosynthetic activity by algae. Changes in pH may alter the concentrations of other substances in water to a more toxic form. Ammonia toxicity, chlorine disinfection efficiency, and metal solubility are all subjective to changes in pH value. However, the most frequently encountered range is 6.5-8.0.WHO (2011), NAFDAC and SON guidelines for acceptable limit for quality drinking water are between6.5 and 8.5. The results presented in Table 3 revealed the various pH levels of the sample sources of water in the study area. From the results, it can be observed that all the sample of the study fall within NAFDAC, SON, and WHO guideline for safe drinking water, ranging from a pH value of 5.00-6.69.

Figure 3: pH Concentration



	pH
Sample 1 (Well)	5
Sample 2 (Public Bore Hole)	6.69
Sample 3: (Estate Bore Hole)	6.53
NAFDAC & SON Limit	8.5

Source: Laboratory analysis, 2019.

g) Conductivity (µS/cm)

Electrical conductivity is the ability of any medium; water in this case, to carry an electric current. The presence of dissolved solids such as calcium, chloride, and magnesium in water samples carries the electric current through water. According to NAFDAC and SON, the maximum allowable (limit) of conductivity is 100*µS/cm.* The results show that the measured conductivity of all water samples ranges from103*µS/cm* to119.2*µS/cm* (Table 3). From the results it can be observed that all the sample sources had conductivity above the NAFDAC and SON approved limit for drinking water in the study area.

The variation in conductivity usually can be explained as the reverse osmosis treatment technique is used to remove dissolved solids, turbidity, colloidal matters, and others, and thus it gives lowest conductivity value. Similarly, it is expected to find high mineral contents in mineral water, which resulted in higher conductivity value Scatena (2000) explained the differences based on various factors such as agricultural and industrial activities and land use, which affect the mineral contents and thus the electric conductivity of the water. Conductivity does not have direct impact on human health. It is determined for several purposes such as determination of mineralization rate (existence of minerals such as potassium, calcium, and sodium) and estimating the number of chemical reagents used to treat this water (Kavcar, Sofuoglu, & Sofuoglu, 2009; Cidu, Frau, & Tore, 2011; Muhammad, Shah, & Khan, 2011; Khan, Shahnaz, Jehan, Rehman, Shah, & Din, 2013).

High conductivity may lead to lowering the aesthetic value of the water by giving mineral taste to the water. For the industrial and agricultural activity, conductivity of water is critical to monitor. Water with high conductivity may cause corrosion of metal surface of equipment such as boiler. It is also applicable to home appliances such as water heater system and faucets. Food-plant and habitat-forming plant species

are also eliminated by excessive conductivity (Jia, Qin, & Liu, 2010; Katsoyiannis & Zouboulis, 2013; Tuzen & Soylak, 2006; Heydari & Bidgoli, 2012; Pillay, Hoo, & Chu, 2001).

h) Total Hardness (mg$CaCo_3$/l)

Generally, the total hardness is function of the geology of the area with which the surface water is associated. Hardness has no known adverse influences health; nevertheless, some evidence has been given to point out its impact on heart diseases (Wright, 2010). From the result depicted in Table 4.3, sample 1 and 3falls within the approved water quality limit of NAFDAC and SON, with total hardness ranging from 82 to 85*mg*$CaCo_3$/l. The result from sample 2 had a hardness of 105*mg*$CaCo_3$*/l,* which is above the approved limit of 100*mg*$CaCo_3$/l by NAFDAC and SON.

i) Total Dissolved Solid [TDS] (mg/l)

Usually, high total dissolved solid [TDS] concentration is attributed to presence extreme anthropogenic activities along the water course and runoff with high suspended matter (WHO, UNESCO & UNEP, 2001). All the sampled water sources in the study area had levels of TDS content which met the WHO guideline standard value of 1000 *mg/l* as well as NAFDAC and SON guideline standard. The TDS content values ranged from 50.3 to 60.6*mg/l.* Sample 1 had a TDS level of 60.6*mg/l,* while sample 2 had a TSD level of 50.7*mg/l.* sample 3 had a TDS concentration of 50.3*mg/l.*

j) Total Suspended Solid [TSS] (mg/l)

Normally, soil erosion considers the source for suspended solids that comes from the surrounding area caused by human activities. For example, rainy season stations recorded the highest value of TSS due to the rainy days which stimulated serious erosion on the two sides of the riverbanks along the river (Al-Badaii, Shuhaimi-Othman, & Barzani, 2013).TSS content levels of the samples ranged from 2.0 to 14.0*mg/l.* The least level was recorded in sample 2 and 2 respectively (2.0*mg/l*). The highest level was obtained at sample 3 (14.0*mg/l*) which above 10*mg/l* allowable NAFDAC and SON limit for drinking water quality.

k) Chloride Ions, [Cl^-](mg/l)

The presence of Cl^- in the waters is generally due to the nature of lands traversed. They are found in almost all-natural waters (Degbey, Makoutode, Agueh, *et al.,* 2011).WHO guideline values recommend the range of values from 0.5*mg/l*and 2*mg/l* for free residual chlorine in drinking water, while NAFDAC and SON recommend the concentration value of not above 250*mg/l.* A maximum value of 45.0*mg/l* was measured in sample 1, while sample 2 measured a value of 23.5*mg/l*, while a minimum value of 19.9 was measured in sample 3. These results fall within the acceptable limit for drinking water quality by NAFDAC and SON, but above the recommended values by WHO guideline value.

l) Sulphate (SO_4mg/l)

According to Hem (1985), the major sources of sulphate in rivers are rock weathering, volcanoes, and human activities such asmining, waste discharge, and fossil fuel combustion process. The presence of sulphate in drinking water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers (WHO, 2004). According to WHO (2008) guideline values recommend sulphate concentration of 250*mg/l*. Similarly, NAFDAC and SON recommended the same concentration value (250*mg/l*) limit for drinking water quality. From the results presented in Table 4.3, all sampled water falls within this limit, with a maximum value of 35.7*mg/l* measured in sample 1, 29.0*mg/l* in sample 2, and a minimum value of 19.9*mg/l* measured in sample 3 respectively.

m) Dissolved Oxygen [DO] (O_2 mg/l)

Dissolved oxygen refers to the level of free, non-compound oxygen present in water (Horne & Goldman, 1994; Makwe & Chup, 2013). The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chemical or biological processes taking place in the distribution system. Healthy water should generally have dissolved oxygen concentration of above 6.5*mg/l* and 8*mg/l* (Horne & Goldman, 1994). There is no health-based guideline value recommended for dissolvable oxygen in drinking water, however, low dissolvable oxygen can encourage microbial reduction of nitrate to nitrite and sulphate to sulphide, giving rise to anaerobic condition, putrefaction and development of foul odour while very high levels of dissolvable oxygen may exacerbate corrosion of metal pipes (WHO, 2012; Makwe & Chup, 2013). In the case of allowable limit, there is none recommended by NAFDAC and SON. The results obtained from all sampled water were within the recommendations made by Horne and Goldman (1994). From the results of the samples of water (Table 4.3), it can be observed that sample 1 had a dissolvable oxygen measure of 6.9*mg/l*, while sample 2 recorded dissolvable oxygen of 7.1. Sample 3 recorded a measure of dissolvable oxygen of 6.8*mg/l* respectively.

n) Biological Oxygen Demand (BOD mg/l)

According to Gasim, Ismail, Wan, Muhammad, and Marlia, (2005), the concentrations of biological oxygen demand varied from 2.4 to 19.8mg/L which are considered high if compared to this study, given the results obtained from the sampled water and the allowable limits by NAFDAC and SON (5*mg/l*). The results revealed a maximum biological oxygen demand measure in sample (7*mg/l*), which is above NAFDAC and SON allowable limit. However, the measure of biological oxygen demand from sample 2 and 3 fall

within the allowable limits of NAFDAC and SON (5*mg/l* respectively).Usually, biological oxygen demand concentration continuously increases because of natural plant decaying process and other contributors that increase the total nutrient in water bodies such as fertilizer, construction effluent, animal farm, and septic system (Al-Sabahi, 2007).Biological oxygen demand concentration is directly associated with dissolvable oxygen concentrations. High value of biological oxygen demand shows decline in dissolvable oxygen. This phenomenon is common as identified in many previous researches (Rosli, Gandaseca, Ismail, & Jailan, 2010).

o) Chemical Oxygen Demand (CO mg/l)

The chemical oxygen demand (COD) concentrations of water samples were fluctuating between minimum of 7.8*mg/l* (sample 3), and 8.2*mg/l* (sample 2) and a maximum of 13.5*mg/l* (Sample 1). It is important to note here that sample 2 and 3 are within the standard allowable limit of NAFDAC and SON (<10*mg/l*), while sample 1 was above the allowable limit (13.5*mg/l*> 10*mg/l*). Generally, the lower chemical oxygen demand level indicates a low level of pollution, while the high level of chemical oxygen demand points out the high level of pollution of water in the study area (HACH, 2003). Moreover, a wide usage of chemical and organic fertilizer and discharge of sewage affect chemical oxygen demand level, while the high chemical oxygen demand pointing to a deterioration of the water quality is attributed to the discharge of municipal effluent (Eisakhani, & Malakahmad, 2009).

IV. Conclusion

Water quality in simple terms pertains to the physical, chemical and microbiological characteristics of water relative to its specific use. The study found that well water source was the most polluted source of water, as a result of exposure to different materials making it prone to high concentration of physical, chemical and microbiological properties. By way of qualitative description, well water has the highest concentration of physical and microbiological properties of water. With NAFDAC and SON permissible guidelines for potable water not adhered to be people, it is therefore the collective responsibility of both private and public sectors for ensuring effective management of water sources for greater sustainability. Furthermore, the research has provided explanatory information on the quality status (Physical, Chemical and Microbiological) parameters of three common sources of drinking water in Gosa, FCT, Abuja.

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Uso De Energia Fotovoltaica Em Uma Propriedade Rural De Fruticultura: Perspectivas E Viabilidades

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Resumo- A geração de energia fotovoltaica apresenta um bom rendimento durante o ano inteiro, e outra vantagem frente as outras fontes de energia no Brasil estão relacionadas ao baixo investimento na geração de energia elétrica e a preservação do meio ambiente. O objetivo do presente estudo foi avaliar a viabilidade de uso de sistemas de geração de energia solar fotovoltaica (SFV), para suprir e/ou complementar as necessidades energéticas de uma propriedade rural de bananicultura irrigada, no Sul do estado do Mato Grosso, localizada no município de Rondonópolis. A análise de dados consistiu em coletar as informações de consumos das unidades consumidoras do proprietário rural, das taxas de reajustes tarifários, do IPCA e SELIC para efeito comparativo do investimento e processados de forma a permitir a análise e a viabilidade econômico-financeira da tecnologia fotovoltaica, através dos cálculos do VPL, TIRe *payback*, e obtendo resultados aceitáveis as hipóteses do investimento no SFV, na propriedade rural de estudo.

Palavras-Chave: *energia elétrica na irrigação, sistema fotovoltaico na irrigação, viabilidade econômica de um SFV.*

GJSFR-H Classification: *FOR Code: 059999p*

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Uso De Energia Fotovoltaica Em Uma Propriedade Rural De Fruticultura: Perspectivas E Viabilidades

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Resumo- **A geração de energia fotovoltaica apresenta um bom rendimento durante o ano inteiro, e outra vantagem frente as outras fontes de energia no Brasil estão relacionadas ao baixo investimento na geração de energia elétrica e a preservação do meio ambiente. O objetivo do presente estudo foi avaliar a viabilidade de uso de sistemas de geração de energia solar fotovoltaica (SFV), para suprir e/ou complementar as necessidades energéticas de uma propriedade rural de bananicultura irrigada, no Sul do estado do Mato Grosso, localizada no município de Rondonópolis. A análise de dados consistiu em coletar as informações de consumos das unidades consumidoras do proprietário rural, das taxas de reajustes tarifários, do IPCA e SELIC para efeito comparativo do investimento e processados de forma a permitir a análise e a viabilidade econômico-financeira da tecnologia fotovoltaica, através dos cálculos do VPL, TIRe *payback*, e obtendo resultados aceitáveis as hipóteses do investimento no SFV, na propriedade rural de estudo.**

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I. Introdução

A recente crise hídrica no país, apresentou-se baixos níveis de água nos reservatórios, e de acordo com o Plano Nacional de Expansão de Energia 2050 - PNE 2050, levam à utilização frequente das térmicas até 2050. Este fato impacta diretamente sobre as tarifas de energia elétrica.

Como a energia fotovoltaica que tem despertado o interesse em todos as classes consumidoras de energia elétrica devido a possibilidade de reduzir os custos com energia elétrica, torna-se um dos atrativos em se ter umSFV, isentando dos encargos tributários federais como PIS, CONFINS que passaram a serem isentos através da Lei 13.169/2015 (BRASIL, 2015a), para a energia solar e, pelo Convênio 16/2015 (BRASIL, 2015b) o estado de Mato Grosso aderiu em 01/01/2016 a isenção do ICMS aos sistemas de geração distribuída conectados à rede com base na resolução normativa 482/2012 da ANEEL (ANEEL, 2012).

A aquisição de equipamentos do SFV, não poderia ser diferente com o proprietário da bananicultura irrigada localizado na região sul do estado de Mato Grosso, no município de Rondonópolis, objeto deste estudo, que em relação aos custos com a produção, a terra, mudas, mão de obra, insumos, energia elétrica, irrigação, etc., despertou o interesse do produtor rural, no sentido de reduzir custo ao menos em relação à tarifa de energia elétrica, com a implantação de um SFV de geração distribuída de energia elétrica.

O que proporcionou essa viabilidade, foram as resoluções da Agência Nacional de Energia Elétrica (ANEEL), como a 482/12 e 687/15 que regulamentavam a mini e a micro geração de energia para uso particular, autorizando a geração de energia elétrica distribuída nas propriedades, a ligação dessas pequenas centrais produtivas ao sistema de distribuição das concessionárias de energia elétrica, permitindo a disseminação de qualquer tipo de geração de energia renovável e limpa, com limite de geração de até 5,0 MWp.

De acordo com (PEREIRA *et al*., 2017), o nível de radiação da região Sul do estado de Mato Grosso, objeto deste estudo, é de 5,51 KWh/m^2. O produtor atentou-se as prerrogativas da geração distribuída, e o uso da energia fotovoltaica, para que a análise feita para avaliar se aceita ou rejeita um projeto de um SFV. Levando-se em conta ele possui três unidades consumidoras(UC´s) e as três unidades consumidoras devem possuir suas contas de consumos com a mesma titularidade, para que, os créditos de energia elétrica devido a geração distribuída passam a ser abatidos nas contas de energia elétrica.

Com os valores médios em KWh das UC´s de suas faturas de energia elétricas, obteve-se o consumo dos últimos doze meses e de posse dessa informação, acessando o site do "Portal solar", consegue-se um orçamento do SFV praticado pelo mercado, com a finalidade de levantar as informações para as análises de viabilidade econômica do investimento inicial a ser feito para instalação da fonte geradora de energia fotovoltaica.

Com a prática da irrigação a bananicultura tem sua produção assegurada anualmente, garantindo uma colheita com produção estimada de 600 caixas por

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semana na propriedade rural onde deseja-se avaliar a viabilidade de instalação do SFV. E é um estudo continuado de pesquisa devido as constante evoluções e tecnologias do SFV, e mediante os enfrentamentos econômicos das receitas e despesas nas propriedades rurais, serve como mais um norte em relação aos investimentos para diminuir custos e realocar em outras necessidades do agricultor.

II. Material E Métodos

O objeto deste estudo é a propriedade rural denominada "Sitio Sonho Meu", que fica no assentamento Portal do Areia, com localização geográfica 16 ° 19' 54,1" S e 54 ° 20' 29,4" W, na cidade de Rondonópolis, no estado de Mato Grosso. A produção de banana é feita em uma área de 18 hectares, dividido em 20 quadras. O solo tem característica arenosa, com uma lavoura de banana, num total de 1600 plantas por hectare, e é irrigada por micro aspersão, com uma média de 80 Lh-1 para cada aspersor.

O objetivo do estudo foi o de avaliar a viabilidade econômica e as perspectivas do uso de energia elétrica fotovoltaica em uma propriedade de bananicultura irrigada; determinar o investimento inicial da instalação do sistema de energia fotovoltaica (SFV), e a sua comparação com os custos envolvidos na instalação referente a energia elétrica convencional. Usou-se como ferramentas de análise para as tomadas de decisão, se aceita ou rejeita o projeto, os indicadores financeiros; como o *payback*, TIR (taxa de retorno do investimento) e VPL (valor presente líquido).

Este estudo buscou a metodologia de um estudo de caso, para analisar a viabilidade econômica da implementação de painéis fotovoltaicos para a geração distribuída de energia solar fotovoltaica conectada à rede de distribuição da concessionária de energia elétrica de MT, de uma área de bananicultura, conforme os dispositivos das resoluções da ANEEL, que versa sobre geração distribuída. Quanto à abordagem, a pesquisa caracteriza-se como quantitativa, visto que objetivou calcular a viabilidade econômica do uso dos sistemas fotovoltaicos. Com relação ao tipo de pesquisa, considera-se como exploratória, pois não existem na região Sul do estado de Mato Grosso relatos da utilização de painéis fotovoltaicos em uma área de plantação de banana.

O setor de fruticultura está entre os principais geradores de renda, emprego e de desenvolvimento rural do agronegócio nacional (FACHINELLO *et al*., 2011). A propriedade rural em estudo, produz a banana nanica com duas variedades, sendo a Willlians e Grand Naine.

Buscou dimensionar o tamanho do sistema de geração de energia fotovoltaica e o investimento, através do consumo médio de energia nas três UC's informados pelo proprietário. Obteve-se um orçamento no site Portal Solar (2019) contendo um valor médio praticado no mercado referente ao custo para implementação do sistema e tendo condições de projetar os resultados financeiros.

O procedimento de obter o consumo, em KWh, para a implementação da geração distribuída de energia elétrica, foi através das referidas UC´s, somando o consumo médio mensal dos últimos doze meses, que vem na fatura de cada unidade e obteve-se um total de 2.388 KWh, de acordo com o quadro 1.

Quadro 1: Consumo mensal, no ano de 2018, das três unidades consumidores (UC) deste estudo, e o total geral do ano de 2018Mês / 201

Mês / 2018	UC 1481163	UC 706436	UC 2526735	Soma kWh médio das 3 UC´s.
Jan	1102	1189	213	
Fev	100	1954	262	
Mar	1013	1246	346	
Abr	919	1261	241	
Mai	100	1196	329	
Jun	819	1251	189	
Jul	726	1265	183	
Ago	100	1584	171	
Set	2902	1019	227	
Out	0	1426	273	
Nov	66	1944	268	
Dez	100	1376	231	
Média últimos meses (kWh)	764	1393	231	2388

Fonte: Energisa (2019).

III. Resultados e Discussão

Para a análise de investimentos, foi necessário determinar uma taxa mínima de atratividade (TMA), utilizando-se os últimos cinco reajustes tarifários concedidos pela ANEEL à concessionária de energia elétrica do Estado, Energisa Mato Grosso S.A. (EMT) conforme Quadro 2.

Quadro 2: Percentuais de reajustes tarifários aplicados pela Energisa nos últimos cinco anos.

Ano	Taxa de Reajuste Tarifário (%)
2014	11,16
2015	22,08
2016	9,15
2017	-1,85
2018	14,04

Fonte: Energisa (2019).

No *site* Portal Solar, insere-se os 2.388 KWh de consumo médio obtidos nas faturas de energia elétrica das 3 UC´s, referência janeiro/2019 emitido pela concessionária, onde consta em um campo da mesma "média últimos meses (kWh)", obtendo-se um valor de R$ 84.399,00, que é um preço médio praticado no mercado de energia solar para construção de um sistema gerador de energia fotovoltaica (PORTAL SOLAR, 2019). De acordo com os dados do Instituto para o Desenvolvimento de Energias Alternativas da América Latina (IDEAL), a composição do sistema fotovoltaico (SFV) está mostrada na tabela 1 (IDEAL/AHK-RJ (2018).

Tabela 1: Composição do sistema fotovoltaico e o rateio de cada componente da composição

Composição típica do SFV	%	Diluição do Valor (R$)
Estruturas metálicas de suporte telhado	10	8.433,90
Projeto e instalação	14	11.807,46
Outros (instalações, proteções, etc.)	7	5.903,73
Custos e despesas administrativas	10	8.433,90
Módulos fotovoltaicos	38	32.048,82
Inversores	21	17.711,19
Valor total do investimento R$		84.339,00

Fonte: IDEAL/AHK-RJ (2018).

Pelo site Portal Solar, o valor de R$ 84.339,00, considera-se 60 módulos solar de potência 330Wp cada, com a potência instalada de 19,80 kWp. O SFV tem uma vida útil de 25 anos, o que por si só, torna-se muito interessante, por sugerir uma longa vida útil do sistema. Utilizou-se nos módulos solares, o modelo YGE 72 CELL SERIES 2, com formato 1.960mm x 992mm x 40mm (comprimento x largura x altura). Como são 60 módulos, a área ocupada pelo sistema é de aproximadamente de 120 m^2.

Ao posicionar os módulos fotovoltaicos, deve-se garantir a orientação e inclinação ideais, assim como, evitar ao máximo pontos de sombra sobre o sistema. A orientação em direçãodo Norte geográfico, para que os módulos fiquem expostos à luz solar uma maior quantidade de horas possível ao longo do ano. E a inclinação para maximizar a geração de energia, o ângulo ideal de inclinação equivale ao valor da latitude do local de instalação. No caso da localização da propriedade em estudo, a inclinação dos módulos deve ser de aproximadamente de 17 graus (Figura 1).

Figura 1: Localização da possível instalação dos módulos fotovoltaicos

A escolha do local para a instalação, e o posicionamento dos painéis são fatores extremamente decisivos na eficiência do sistema. Na propriedade em estudo, a opção pode ser escolhida tanto no telhado quanto no solo. O ideal é escolher locais livres de estruturas que possam causar sombreamento a qualquer horário do dia, tais como árvores, ressaltos e edificações vizinhas. O telhado tem um melhor aproveitamento da insolação, enquanto que, de acordo com Souza (2018) a instalação de geradores fotovoltaicos no solo exige a escolha e o projeto do tipo de fundação mais adequado. Ainda, segundo Souza (2018), A fundação tem por objetivo manter a orientação adequada da estrutura de suporte do gerador fotovoltaico com relação ao sol e evitar danos ao conjunto durante ventos fortes. Ao se escolher a fundação mais indicada para a montagem de um gerador, deve-se considerar fatores como o acesso ao local, condições climáticas extremas, a topografia, as propriedades do solo, o código de obras local e a disponibilidade de mão de obra, dentre outros fatores que aumentariam por demais os custos para construção em praticamente 100%. Com isso, o telhado torna-se a melhor opção.

Na figura 1 tem-se metade do telhado caracterizado uma possível instalação para o arranjo dos painéis fotovoltaicos, onde fica o barracão que armazena as bananas colhidas, equipamentos e máquinas, cujas dimensões são 17 x 25 m, sendo que os módulos podem ser instalados em um lado do telhado, chamado de água, aquele voltado para o Norte geográfico, para melhor aproveitamento na geração de energia elétrica.

A base de dados para a determinação dos valores das partes da composição típica de um SFV foi o período de 2014 até 2018, com um percentual de reajuste por kWh no período de 10,91%. Esse foi a TMA aplicada para a análise do investimento. O valor da tarifa com os tributos usados foi a média das três unidades consumidoras, pois, são de diferentes classes de consumo (residencial, residencial rural e rural agropecuária), sendo uma monofásica de valor R$ 0,520830 o kWh, a bifásica com valor R$ 0,821030 o kWh e a trifásica, o valor de R$ 0,422200 o kWh, resultando um valor médio de tarifa de R$ 0,588020.

Em relação aos 2.388 kWh encontrados, que é a média da soma das três UC´s, embutidos a disponibilidade energética nesse total, e então, para definir como atrativo um projeto em que o fluxo esperado de benefícios financeiros, deve superar o valor inicialmente investido no projeto (TREASY, 2018). Não se pode deixar de retirar o custo de disponibilidade da classe de consumo, que são o mínimo de kWh cobrados pela concessionária, mesmo o consumidor não usando o sistema. Tem-se para os tipos de categorias o mínimo cobrado pela sua disponibilidade: o monofásico de 30 kWh, bifásico 50 kWh e, o trifásico de 100 kWh. Retirando o valor da disponibilidade das três unidades consumidoras, que somados dá um total de 180 kWh, do valor inicial encontrados de 2.388 kWh, retira-se a soma da disponibilidade da UC´s, ficando o valor de kWh usado para avaliar os benefícios financeiros acerca do SFV, num total de 2.208 kWh.

Tabela 2: Demonstrativo do fluxo de caixa para análise do investimento e cálculo do *payback*, do VPL e do TIR

A	T	Consumo	Tarif	Compensação	Fluxo de caixa
0				-84.339,00	-84.339,00
1	0	2208	1.29	15.580,18	-68.758,82
2	0	2208	1.44	17.279,98	-51.478,85
3	0	2208	1.59	19.165,22	-32.313,63
4	0	2208	1.77	21.256,15	-11.057,48
5	0	2208	1.96	23.575,19	12.517,71
6	0	2208	2.17	26.147,25	38.664,96
7	1	2208	2.41	28.999,91	67.664,87
8	1	2208	2.68	32.163,80	99.828,67
9	1	2208	2.97	35.672,87	135.501,54
1	1	2208	3.29	39.564,78	175.066,32
1	1	2208	3.65	43.881,30	218.947,62
1	1	2208	4.05	48.668,75	267.616,36
1	2	2208	4.49	53.978,51	321.594,87
1	2	2208	4.98	59.867,56	381.462,43
1	2	2208	5.53	66.399,11	447.861,55
1	2	2208	6.13	73.643,26	521.504,81
1	3	2208	6.80	81.677,74	603.182,54
1	3	2208	7.54	90.588,78	693.771,32
1	3	2208	8.37	100.472,01	794.243,34
2	4	2208	9.28	111.433,51	905.676,85
2	4	2208	10.2	123.590,91	1.029.267,75
2	5	2208	11.4	137.074,67	1.166.342,43
2	5	2208	12.6	152.029,52	1.318.371,95
2	6	2208	14.0	168.615,94	1.486.987,89
2	7	2208	15.5	187.011,94	1.673.999,83

A opção de cálculo foi o Excel para a composição e cálculo do quadro demonstrativo. O ano refere-se a vida útil do SFV, a tarifa kWh foi feita como base o composição do reajuste tarifário dos últimos cinco anos da concessionária local (Energisa Mato Grosso S.A.), consumo médio kWh/mês, que já vem descontada a disponibilidade de uso no sistema elétrico, a tarifa mensal é o número de kWh multiplicado pela tarifa, a compensação energética anual, é o valor da tarifa mensal multiplicado por 12 (meses do ano) e, por fim, obtém-se o fluxo de caixa acumulado, que desconta o valor inicial do investimento.

Segundo Hoji (2014, p. 167), "... para dar suporte às decisões de investimento, as análises de viabilidade econômica devem ser feitas com métodos e critérios que demonstrem com bastante clareza os retornos sobre os investimentos, considerando os níveis riscos assumidos...".

Com o demonstrativo geral montado na tabela 2 pode-se, através da ferramenta computacional do *Excel*, determinar o *payback*, o VPL e o TIR e, finalmente, fazer as devidas análises sobre o investimento requerido pelo produtor rural de banana.

O *payback* descontado considera o valor do dinheiro no tempo, atualiza os fluxos futuros de caixa a uma taxa de atratividade, trazendo os fluxos a valor presente, para depois calcular o período de recuperação (BRUNI, 2018).

De acordo o quadro demonstrativo, o valor do investimento ficará nulo entre o quarto e o quinto ano, o *payback* dá-se entre o sétimo e oitavo ano do projeto. Pela análise gráfica é possível saber mais precisamente a época que acontece o *payback* (Figura 2).

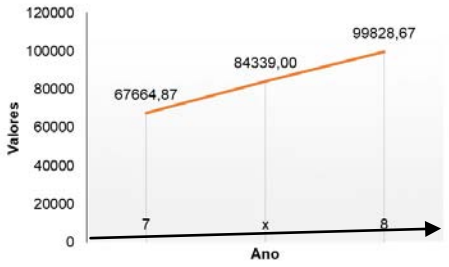

Figura 2: Gráfico demonstrativo do *payback* para determinar o tempo de pagamento do investimento com taxa do IPCA e SELIC

Matematicamente, pode-se encontrar o valor exato do *payback* através de proporção entre triângulossemelhantes, como na figura 2

$$\frac{x}{(84339 - 67664{,}87)} = \frac{8 - 7}{99828{,}67 - 67664{,}87}$$

Obtendo-se o resultado x = 0,52 anos, que somado ao valor inferior 7 anos, encontra-se precisamente o *payback*, isto é, o retorno do investimento inicial, que será 7,52 anos, ou 7 anos, 6 meses e 6 dias.

A medida do Valor Presente Líquido (VPL) é obtida pela diferença entre o valor presente dos benefícios líquidos de caixa, previsto para cada período do horizonte de duração do projeto e o valor presente do investimento (ASSAF NETO e LIMA, 2011).

Conforme a análise de critérios de decisão do VPL, tem-se:

- VPL > 0; projeto cria valor econômico;
- VPL = 0; projeto não cria valor econômico E;
- VPL < 0; projeto destrói valor econômico.

Por meio do uso da tabela 2 do demonstrativo de fluxo de referência, e com o uso do *Excel*, encontra-se VPL com um valor de R$ 266.850,66. Como o VPL deu maior do que zero, sinal que o projeto cria valor econômico.

Para a TIR (Taxa de Retorno de Investimento) que, segundo Gitman (2010), é a taxa de retorno anual composta, que a empresa obterá se investir no projeto e receber as entradas de caixa previstas. Também o TIR tem os seguintes critérios de decisão em relação à taxa mínima de atratividade (TMA):

- TIR > TMA; aceitar projeto;
- TIR < TMA; rejeitar Projeto.

Usando a tabela 2 do demonstrativo de fluxo, ainda, com o uso do *Excel*, encontra-se a TIR igual a 29%, maior do que TMA para esse projeto, que é de 10,91%. A figura 3 apresenta graficamente essas análises.

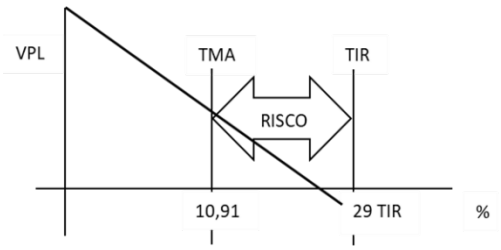

Figura 3: Gráfico da TMA e TIR, sinalizando o risco do investimento

A relação entre o TMA e a TIR pode ser descrita, como quanto mais próximas forem, maior será o risco de o projeto não dar certo e, quanto mais distante, melhor para a validação do projeto.

A tabela 4 apresenta um resumo dos resultados da análise de viabilidade desenvolvida para SFV a ser implantado.

Tabela 4: Resumo geral da análise de viabilidade do projeto do SFV, com os valores encontrados do TMA, VPL, TIR

Investimento Inicial	R$ 84.339,00
TMA (reajuste médio tarifa 2014 a 2018)	10,91%
VPL (Valor presente Líquido)	R$ 266.850,66
TIR (Taxa interna de retorno)	29%

Pelo desenvolvimento dos cálculos, efetuou-se como base o reajuste tarifário concedido pela ANEEL à concessionária de energia elétrica Energisa. Para consolidação da análise, acessou-se o site do Banco Central, no relatório de expectativas de mercado, obtendo-se para o horizonte de 2019 a 2022, valores do índice do IPCA e da taxa SELIC, para uma nova TMA, conforme visto no quadro 3.

Quadro 3: Percentuais do relatório de expectativa de mercado do banco central do IPCA e da SELIC, no horizonte de 2019 a 2022

Ano	IPCA(%)	SELIC (%)
2019	4,04	6,50
2020	4,00	7,50
2021	3,75	8,00
2022	3,75	8,00
Média	3,88	7,50

O TMA foi obtido da média aritmética dos anos apontados no Quadro 3, sendo que para o IPCA foi obtido 3,88% e para a taxa SELIC, o valor de 7,50%. Então, a partir desses dados iniciais foi montado novamente o demonstrativos de fluxos de caixas de análise de investimentos para essas taxas, obtendo-se o *payback*, VPL e TIR de cada taxa. A figura 4 apresenta os gráficos demonstrativos relativos ao IPCA e à taxa SELIC do *payback* para o pagamento do investimento.

Pelo gráfico da figura 4, o resultado obtido para a taxa do IPCA de x = 0,21 ano encontrou o retorno do investimento em 9,21 anos, ou 9 anos, 2 meses e 16 dias. Já, para a taxa SELIC houve uma coincidência, encontrando também x = 0,21 ano, o que determinou o retorno do investimento em 8,21 anos, ou 8 anos, 2 meses e 16 dias.

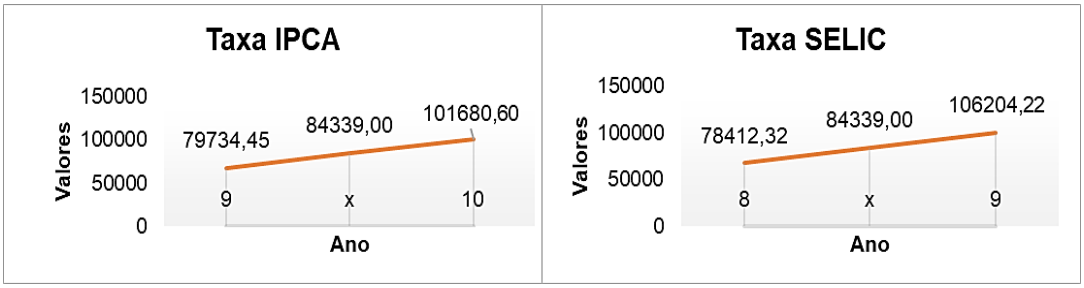

Figura 4: Gráfico demonstrativo do *payback* para determinar o tempo de pagamento do investimento com a taxa do IPCA e SELIC.

Para o resultado do VPL, conforme procedimento efetuado na tabela 2 do demonstrativo de referência, o cálculo foi realizado com o uso do *Excel*, encontrando para o índice do IPCA um valor de R$ 290.617,15, e para a taxa SELIC um valor de R$ 277.990,72. Ambos os valores encontrados produziram um VPL > 0, validando a execução do projeto.

Conforme visto na tabela 2, e no gráfico da figura 5, observa-se que a taxa de retorno de investimento TIR é maior do que o TMA, induzindo a aceitação do projeto. Em relação à análise conjunta do índice IPCA e da taxa SELIC, ambos os resultados foram maiores do que os TMA, implicando na aceitação do projeto.

A tabela 5, apresenta um resumo dos resultados das análises de viabilidade desenvolvida relativa ao SFV, para um TMA referente ao valor dos reajustes tarifários concedidos à Concessionária de energia, e valores do relatório do Banco Central do Brasil, de expectativas de mercado para um cenário de 2019 a 2022, sendo o IPCA e a taxa SELIC como referências para os cálculos.

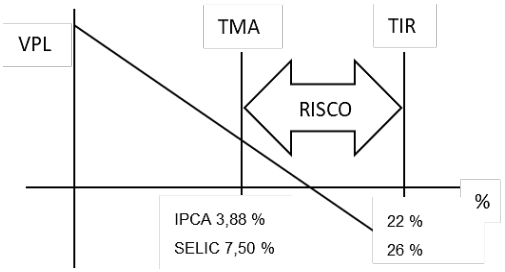

Figura 5: Comparativo do TMA e TIR sinalizando ausência de risco no projeto

Tabela 5: Resumo geral dos resultados obtidos na análise da viabilidade do SFV devido ao reajuste tarifário da Concessionária, relativos ao IPCA e a taxa SELIC

Investimento Inicial	TMA	(%)	VPL (R$)	TIR (%)
R$ 84.330,00	Reajuste tarifa (2014-2018)	10,91	266.850,66	29
	IPCA (2019 -2022)	3,88	290.617,15	22
	SELIC (2019 - 2022)	7,50	277.990,72	26

Observa-se pela tabela 5, que os cálculos demonstraram viabilidade para realizar as tomadas de decisões em aceitar ou rejeitar um projeto, e nos três índices de TMA escolhidos para a análise de viabilidade financeira foram satisfatórios.

Caso o produtor da Bananicultura resolva fazer um financiamento em sua propriedade, o mesmo tem a opção de um crédito voltado para o desenvolvimento econômico e social da Região Centro Oeste, chamado de FCO (Fundo Constitucional de Financiamento do Centro-Oeste), é um fundo de crédito, criado pela Constituição Federal de 1988. As empresas e os produtores rurais que desejam iniciar, manter ou aumentar atividades produtivas na Região podem contar com o FCO para financiamento de seus empreendimentos, com longo prazo de pagamento e taxas de juros menores que os aplicados no mercado.

O Banco Central do Brasil através da Resolução nº 4.674, de 26 de junho de 2018 (BRASIL, 2018)define os encargos financeiros e o bônus de adimplência das operações rurais realizadas com recursos dos Fundos Constitucionais de Financiamento para o período de 1º de julho de 2018 a 30 de junho de 2019, e no Art. 1º Os encargos financeiros das operações rurais do FCO de que trata o art. 1º da Lei nº 10.177, de 12 de janeiro de 2001, (BRASIL, 2001), contratadas no período de 1º de julho de 2018 a 30 de junho de 2019, são os seguintes:

1. Nas operações com a finalidade de investimento, inclusive com custeio ou capital de giro associado:
   - Para produtores rurais e suas cooperativas de produção com receita bruta anual de até R$16.000.000,00 (dezesseis milhões de reais): taxa efetiva de juros prefixada de até 5,86% a.a. (cinco inteiros e oitenta e seis centésimos por cento ao ano); ou taxa pós-fixada composta de parte fixa de até 0,19% a.a (dezenove centésimos por cento ao ano), acrescida do Fator de Atualização Monetária (FAM);

Para as situações encontradas ao investimento do SFV, usamos como referências aos indicadores a taxa do reajuste tarifário dado a concessionária, IPCA e SELIC, que foram os TMA de análise. Todas dando o aceite ao projeto. Para situar-se na posição do proprietário da bananicultura, ao invés de um pagamento a vista, o mesmo fazendo um financiamento para a geração fotovoltaica, e pegando na linha de crédito do FCO, colocando juros de 5,86% e a linha de tempo do financiamento sendo de 20 anos.

Diversamente dos 25 anos conforme vida útil do SFV, o enquadramento do projeto fica de acordo com uma das linhas do Fundo. O máximo de 20 anos, estipulado pela linha de crédito do financiamento e definido na Programação do FCO, para um efeito comparativo introduziremos a taxa por dentro, onde as taxas anteriores serão divididas pela taxa do FCO, dando o novo TMA. E recalculando para as novas análises e viabilidades do investimento na geração fotovoltaica da propriedade rural. Divide-se em três situações para novas análise, que são:

- 1ª Situação: Reajuste tarifário com o FCO.

$$TMA\ Novo = \frac{Reajuste\ Tarifário}{FCO} = \frac{1{,}1091}{1{,}0586} = 1{,}047704$$

Dando um novo TMA para efeito de cálculo, sendo o valor de 4,77% e assim faz-se os mesmos procedimentos conforme quadro demonstrativo de fluxo visto anteriormente em outro TMA´s. Determina-se os indicadores para análise.

Tabela 6: Demonstrativo do fluxo de caixa para análise do investimento e cálculo do *payback*, do VPL e do TIR, taxa por dentro Tarifa/FCO

Ano	Tarifa kwh/FCO	Consumo médio kwhmês^{-1}	Tarifa mensal	Compensação energética anual	Fluxo de caixa acumulado
0				-84.339,00	-84.339,00
1	0,5880	2208	1.298,35	15.580,18	-68.758,82
2	0,6143	2208	1.356,48	16.277,70	-52.481,12
3	0,6418	2208	1.417,20	17.006,46	-35.474,66
4	0,6706	2208	1.480,65	17.767,83	-17.706,83
5	0,7006	2208	1.546,94	18.563,30	856,47
6	0,7320	2208	1.616,20	19.394,38	20.250,85
7	0,7647	2208	1.688,56	20.262,67	40.513,51
8	0,7990	2208	1.764,15	21.169,82	61.683,34
9	0,8348	2208	1.843,13	22.117,60	83.800,94
10	0,8721	2208	1.925,65	23.107,80	106.908,74
11	0,9112	2208	2.011,86	24.142,34	131.051,08
12	0,9520	2208	2.101,93	25.223,19	156.274,27
13	0,9946	2208	2.196,04	26.352,43	182.626,71
14	1,0391	2208	2.294,35	27.532,23	210.158,94
15	1,0856	2208	2.397,07	28.764,85	238.923,79
16	1,1342	2208	2.504,39	30.052,65	268.976,44
17	1,1850	2208	2.616,51	31.398,11	300.374,55
18	1,2381	2208	2.733,65	32.803,80	333.178,36
19	1,2935	2208	2.856,04	34.272,43	367.450,79
20	1,3514	2208	2.983,90	35.806,81	403.257,59

O *payback* torna-se nulo entre o 4 e 5 período e/ou ano, sendo que o valor do investimento retorna entre o 9º e 10º período. E abaixo nota-se que pela nova taxa, e cálculo por dentro a TIR está maior que o TMA e o VPL deu um valor positivo. Então o projeto é viável.

Tabela 7: Resumo geral da análise de viabilidade do projeto do SFV, com os valores encontrados do TMA, VPL, TIR,taxa por dentro Tarifa/FCO

Investimento Inicial	R$ 84.339,00
TMA (reajuste tarifário/FCO)	4,70%
VPL (Valor presente Líquido)	R$ 207.330,93
TIR (Taxa interna de retorno)	22%

- 2ª Situação: IPCA com o FCO.

$$TMA\ Novo = \frac{IPCA}{FCO} = \frac{1{,}0388}{1{,}0586} = 0{,}9812$$

Dando um novo TMA para efeito de cálculo, sendo o valor de 98% e assim faz-se os mesmos procedimentos conforme quadro demonstrativo de fluxo visto anteriormente. Determina-se os indicadores para análise.O *payback* torna-se nulo entre o 5º e 6º período e/ou ano, sendo que o valor do investimento retorna entre o 9º e 10º período. E abaixo nota-se que pela nova taxa, e cálculo por dentro a TIR está maior que o TMA e o VPL deu um valor negativo. Então o projeto tornou-se inviável.

Tabela 8: Resumo geral da análise de viabilidade do projeto do SFV, com os valores encontrados do TMA, VPL, TIR, taxa por dentro IPCA/FCO

Investimento Inicial	R$ 84.339,00
TMA (reajuste médio tarifa 2014 a 2018)	98%
VPL (Valor presente Líquido)	R$ -67.785,52
TIR (Taxa interna de retorno)	22%

- 3ª Situação: SELIC com o FCO.

$$TMA\ Novo = \frac{SELIC}{FCO} = \frac{1{,}075}{1{,}0586} = 1{,}01549$$

Dando um novo TMA para efeito de cálculo, sendo o valor de 1,5% e assim faz-se os mesmos procedimentos conforme quadro demonstrativo de fluxo visto anteriormente. Determina-se os indicadores para análise.

O *payback* torna-se nulo entre o 5 e 6 período e/ou ano, sendo que o valor do investimento retorna entre o 10º e 11º período. E abaixo nota-se que pela nova taxa, e cálculo por dentro a TIR está maior que o TMA e o VPL deu um valor positivo. Então o projeto tornou-se viável.

Tabela 9: Resumo geral da análise de viabilidade do projeto do SFV, com os valores encontrados do TMA, VPL, TIR, taxa por dentro SELIC/FCO

Investimento Inicial	R$ 84.339,00
TMA (reajuste médio tarifa 2014 a 2018)	1,55%
VPL (Valor presente Líquido)	R$ 222.508,42
TIR (Taxa interna de retorno)	19%

Pelo presente instrumentos de análise, nota-se que separadamente com os TMA´s aplicados todos foram satisfatório, respondendo positivamente a aceitação do projeto. Quando se fez o cálculo na linha do FCO, como taxa por dentro, resultou no IPCA/FCO um valor negativo do VPL, tornando-se a inviabilidade nessa situação. Mediante os resultados demonstrados separadamente dos TMA´s e dois de taxa por dentro de análise e perspectivas em relação ao investimento de um sistema fotovoltaico, torna-se viável tal sistema fotovoltaico.

IV. Conclusão

Nota-se que a geração distribuída, no caso geração de energia elétrica fotovoltaica no sistema de compensação de créditos, conforme a necessidade e oportunidade em que o produtor rural da bananicultura, fez-se despertar o interesse em investir no SFV, onde com o tempo os seus custos com energia elétrica vão sendo amortizados. Em relação à possível implantação do sistema fotovoltaico, em conjunto com a rede elétrica de energia na bananicultura verificou-se que essa traria contribuições positivas para o negócio e para a propriedade, visto que, o produtor irá economizar com gastos de energia, podendo realocar esses valores economizados em outras atividades e/ou investimentos.

Os resultados do presente estudo de caso, sinaliza que a instalação do SFV na bananicultura resultaria em benefícios futuros, entre eles, a economia com gastos de energia elétrica, a coparticipação entre energia elétrica fornecida pela Concessionária e aquela fornecida pelo SFV.

Finalmente, uma das grandes contribuições deste trabalho, é que, além da economia com as tarifas de energia elétrica praticada no estado de Mato Grosso, que é bem onerosa, é a consciência do proprietário decorrente da contribuição ambiental do investimento por gerar uma energia limpa e renovável.

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Reimagining Indian Urbanism and Design

By A. K. Jain

Abstract- Urban India is passing through the Anthropocene, where humans have permeated everywhere and shape everything. The approaches of sustainable development focus largely on socio-economic and technical aspects, over-riding the human and cultural values. The architectural design, urban planning and environment impact assessment often ignore the social and cultural aspects, leading to increasing carbon footprints.

It needs relooking at cross-cultural realities, underpinning the socio-economic and cultural dimensions and adoption of circular concepts of the resources and development. The trend of walk to work and work from home need reimagining the process of planning and design.

Keywords: *covid 19, migrants, SDG, 4th industrial revolution, digitisation.*

GJSFR-H Classification: *FOR Code: 050299*

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Reimagining Indian Urbanism and Design

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It needs relooking at cross-cultural realities, underpinning the socio-economic and cultural dimensions and adoption of circular concepts of the resources and development. The trend of walk to work and work from home need reimagining the process of planning and design.

In this context, the urbanism must shift from predigital, fossil fuel era to renewables, digital and circular systems. This needs leapfrogging in the areas of combinatorial and discrete optimisation by algorithms, 4D mapping, downloading, networking, presencing, artificial intelligence, big data analytics, the ubiquitous cloud and robotics. The setools aim to address the impending issues of pollution, energy and water shortages and make the buildings and cities green and carbon negative.

Keywords: covid 19, migrants, SDG, 4th industrial revolution, digitisation.

I. Introduction

With Covid 19 pandemic, social instability, climate change and political conflicts along with rapid changes in technology, environmental sustainability, jobs, energy, water, and food are emerging as the key issues of urban development. Whereas the businesses and industries have transformed by fourth industrial revolution and new technologies, such as combinatorial and discrete optimisation, algorithms, complexity theory, artificial intelligence, big data, and the ubiquitous cloud, the architecture and urbanism are still inhibited by predigital era thinking.

The construction is still one of the most inefficient and fragmented industries. The design process is often compartmentalised with limited interactions among engineers, architects, contractors, and financiers. The emerging technologies, such as Automatic Guided Vehicles (AGVs), Robotics Drive Units (RDUs) and adaptive environment-reconfiguring machines have shaken the foundation of urban design and architecture. Mega projects, such as SEZ, industrial hubs, highways, railway corridors and infrastructure projects ongoing all over the country have hefty carbon footprints. These foreclose the possibilities of questioning whether so much of development is even necessary. The new computation simulation methods favour the emergence of efficient carbon neutral and flexible building blocks, which are efficient, economical and unwasteful. It needs a transition from fossil fuel pollution to green, carbon negative buildings and cities by digital and parametric techniques.

The built environment comprises the urban environment, infrastructure and buildings and interactions among the functions, economy, culture, information, citizens and government. These involve complex systems that address and integrate the diverse issues of jobs, economy, social welfare, culture, equality, gender, children, elderly, lifeline services, housing, climate change, air quality, water, energy, mobility, affordability, and governance.

The electronic era is manifesting a dramatic effect on design, its complexity, and dynamic simulations. During the 1980s there was a breakthrough in parametric design inspired by the plants and organic morphology. This gave birth to a new 'organicity'. Learning from the nature's structural systems of nuanced complexity, it was applied to buildings and urban patterns. The biological forms (morphogenesis) are analysed and reconstructed using parametric design models.The term parametric originates from mathematics (parametric equation) and refers to the use of certain parameters or variables that can be edited to manipulate or alter the end result of an equation or a system. By morphological simulations, the shared concepts, computational techniques, formal repertoires, and tectonic logics are developed, which *expand the repertoire and freedom with non-linear curvilinearity and gradient swarm formations.*

According to Patrick Schumacher, by parametricism urban and architectural environments receive an inbuilt kinetic capacity that allows those environments to reconfigure and adapt themselves. The real time registration of use-patterns drives the real time kinetic adaptation. The systematic modulation of morphologies produces the mutually accentuating correlation of multiple urban systems: fabric modulation, street systems, system of open spaces, etc. This implies

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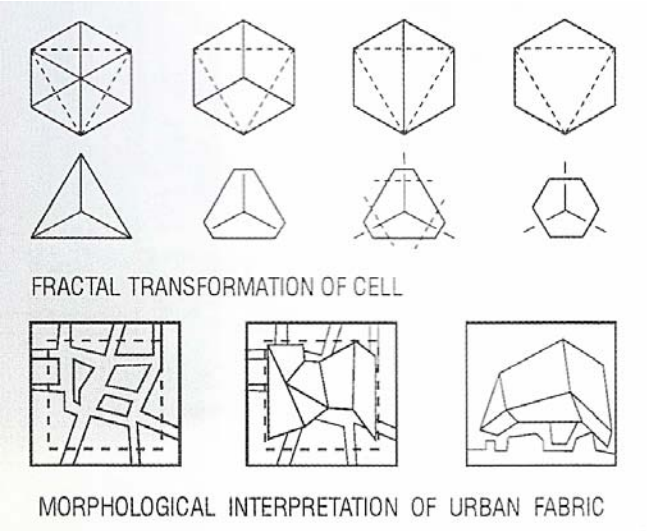
that the fabric modulation extends to the tectonic articulation, fenestration and orientation.



Source: Carlo, Aiello (ed), Evolo Skyscrapers (2012)

Fig. 1: Fractal and Morphological Interpretation of Cells and Urban Fabric

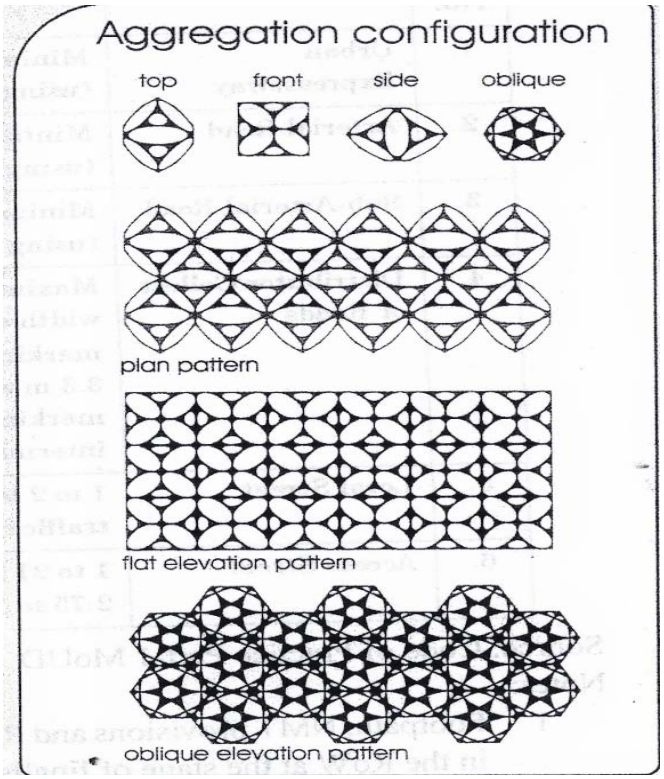
Computer technology provides the tools to analyse and simulate the complexity observed in nature and apply it to building shapes and spatial patterns by use of moving picture and animate forms. Parametric programs, algorithms, and computers can manipulate the elements of design as a self-referential system, in which all the elements are interlinked.

Parametricism aims to achieve spatial complexity while maintaining legibility and adapt to contexts. It uses tools and engines of digital animation software and advanced computational processes. Parametric design is built around the intersection of three areas of knowledge: cognitive models, digital models of design, and parametric tools and scripts. The flow of digital information can be applied for performance-based, generative design from conception to production.

Traditional visual and geometrical representation of the design can be transformed by the 3D Rhino modelling, Grasshopper system and other tools. These enablesa parametric relationship among the topological structures, mathematics, and associative geometry. The parametric process comprises six taxonomies: morphogenetic, geometry and natural system, mathematical algorithms, computation, digital fabrication and production. Parametric design involves thinking with abstraction, thinking mathematically, and thinking algorithmically. This is a new way of relating tangible and intangible systems into a design proposal, integrating topological patterns within generic typologies.

II. Morphogenetic, Geometry and Biomimetics

Morphogenetic is derived from the Greek terms 'morphe' (shape/form) and genesis (creation), used in the biological sciences. It refers to 'the logic of form generation and pattern-making in an organism through processes of growth and differentiation'. Morphogenetic form is not predefined but emerges from the rules that define it.



Source: Architecture+ Design, Horizontal Skyscraper in Carlo, Aiello (ed), Evolo Skyscrapers (2012)

Fig. 3: Aggregation Configuration

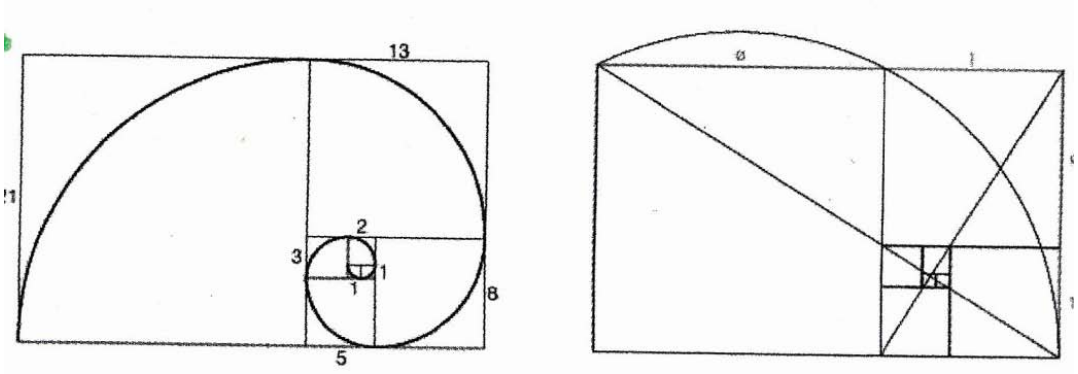


Fig. 3: Fibonacci Sequence and Golden Ratio

Biomimetics or biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. It has emerged as an important field of research and is having particular resonance in morphogenetic architecture. Nature has always been an inspiration, as the works of Frank Lloyd Wright and Antonio Gaudídemonstrate.

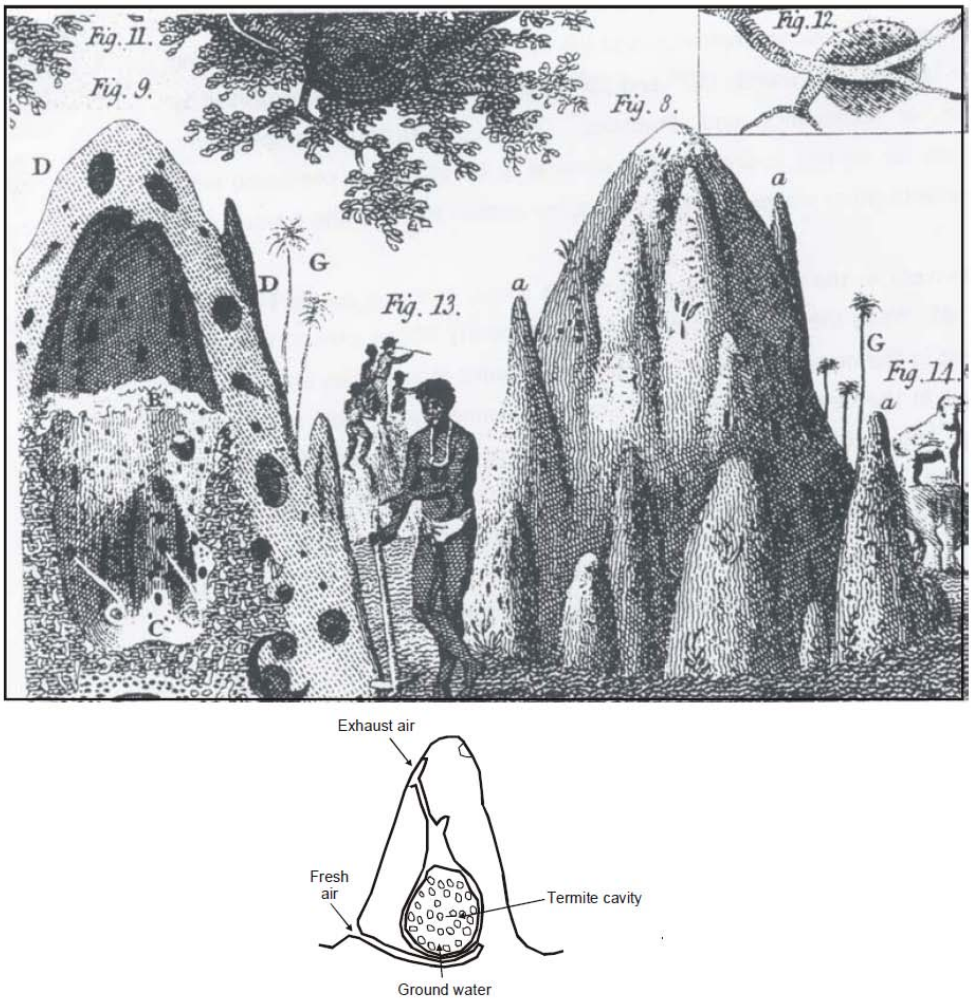


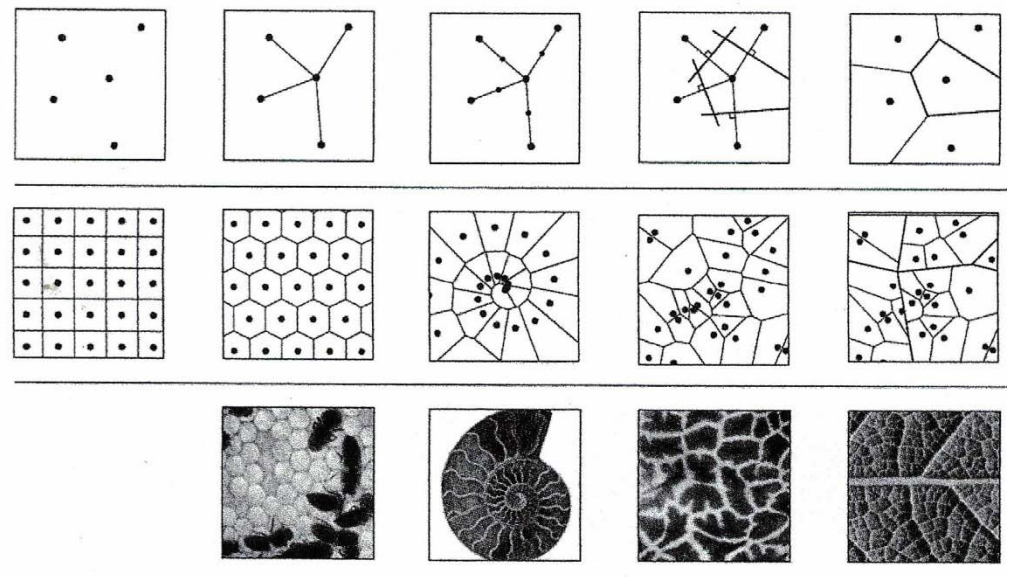
Fig. 4: Termites Nestby Henry Seathman(1781) shows within it miniature streets, bridges, canals, food stores, nurseries, guard rooms, and a royal palace. Termites construct their structures with natural ventilation, thermal storage and evaporative cooling. Through orientation, the nests are protected from overheating in hot climate. Each nest is separated from the outer walls and stands on columns. Spaces are connected and ventilated via vertical tubes and the porous walls.

a) Complex Adaptive Systems

Complex Adaptive Systems (CAS) depend on extensive interactions, the aggregation of diverse elements, and adaptations. These can be seen in the collective intelligence of biological systems, such as a colony of ants, termites' nest, slime mould, flocking birds or a school of fish. Termites' nest is an excellent example of natural ventilation, thermal storage and evaporative cooling. The morphology of traditional cities like Jaipur is an example of community living, occupations, organisation and climatization. Although unpredictable outcomes may emerge, the results are intrinsically connected through the rules that govern them.

b) Voronoi

Named after Georgy Voronoi, a Voronoi diagram is a partitioning of a plane into regions based on distance to points in a specific subset of the plane. A set of points (called seeds, sites, or generators) is specified beforehand, and for each seed there is a corresponding region consisting of all points closer to that seed than to any other. These regions are called Voronoi cells.



Source: Burry, Jane & Mark (2012) The New Mathematics of Architecture, Thames and Hudson, London

Fig. 5: Voronoi Diagrams

c) Mathematical Algorithm

An algorithm is a process of addressing a problem in a finite number of steps. It can be an articulation of either a strategic plan for solving a known problem or a stochastic search towards possible solutions to a partially known problem. Algorithms are expressed in terms of mathematical equations which define the rules of the model.

d) Parametric Modelling

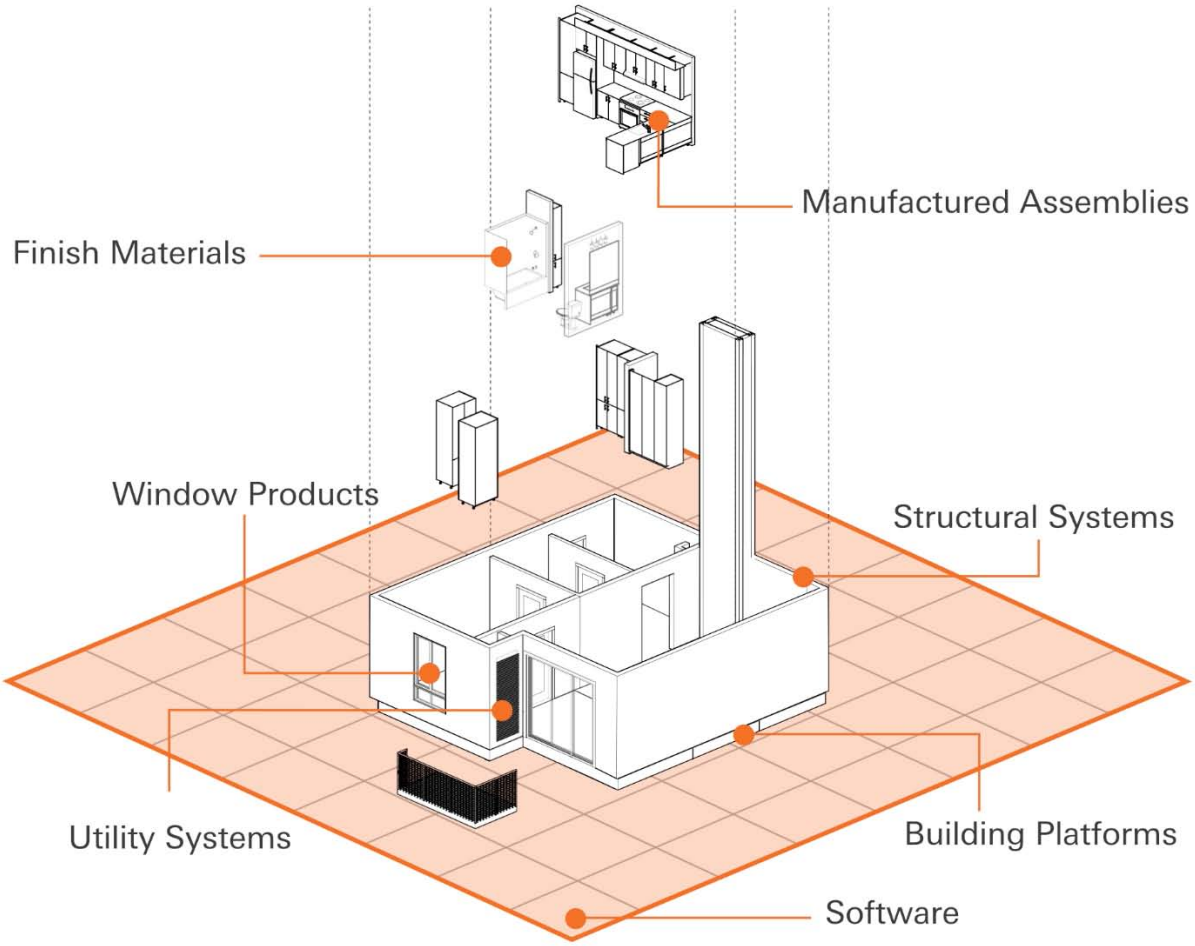
Parametric modelling is based on a series of pre-programmed rules or algorithms known as 'parameter'. The model or elements of it are generated automatically rather than by being manual manipulation. Typically, parametric rules create relationships between different elements of the design. For example, a rule might be created to ensure that walls must start at floor level and reach the underside of the ceiling. Then if the floor to ceiling height is changed, the walls will automatically adjust.

Soft modelling focuses on the control of flexible materials aiming to automate the creation of a discrete line-based structural frame from a membrane. Parametric model engages directly with the BIM to generate, extract and manipulate data. It can also be used to perform analyses and embed the results into the building/planning model.

e) Digital Robotics, Fabrication and Production Process

Digital fabrication uses design-to-fabrication workflows to enable a faster construction process, minimise resources, and material-specific design solutions. It integrates design, simulation, and digital fabrication to create complex, customized products using ubiquitous manufacturing hardware. Digital manufacturing has facilitated opportunities of surface patterning and the fabrication of offsite special building components, removing the constraints of standardisation in the construction industry.

Material feedback allows adjusting the digital fabrication in order to negotiate material properties and to calibrate a precise relation between the whole and the individual units of construction.



Source: Kattera, Key Assemblies, and Curtis, Craig (2020) Architecture at Scale: Reimagining One-Off Projects as Building Platforms Architectural Design

Fig. 6: End-to-end control of building design, manufacturing, construction, and operations achieve targets at lower cost and time

III. Reimagining the City

Cities have become sources of extreme inequality and environmental degradation, which are threatening their physical social and economic integration. Urban planning has long been governed by the classification of human activities-work, residence, leisure and transport. However, this approach is ill-suited to address the pressing environmental, economic and equity concerns. There is a need to adopt a new ecosystem, which addresses the challenges of the environment and urban complexities. The new perspective is mediated by the ecology, technology, connectivity, producing its own energy, transport, food, shelter and recycling of wastes.

It is necessary to overcome the visual chaos of *laissez faire* urbanisation, and focus more upon identity, local culture, topography and climate. The cities and buildings must be not only smart and sustainable but also act as urban nebulisers and transducers in order to detox the air, and function as bioreactor and energy generators. They should enable waste recycling, urban farming and provide green loops which integrate building resources, non-linear geometry and nanotechnology.

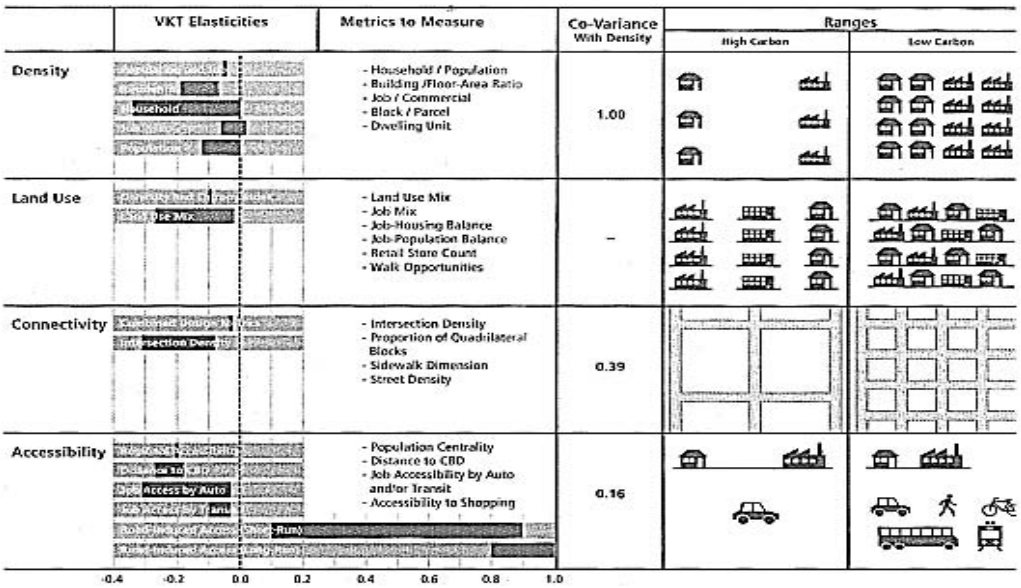
With the sustainability at the centre-stage, it is necessary to work out the approaches that can respond to the needs of 600 million urban population in India by 2031, as well as meet the SDG targets of sustainable cities and communities. These challenges need a new ethics and process of planning and development, which is low carbon and climate resilient.

According to the Intergovernmental Panel on Climate Change (2014 WG III), urban areas account for 67 to 76% of global energy use and 71 to 76% CO_2 emissions. According to the IPCC, the critical aspects of spatial planning for clean air comprise:

- Density and Floor Area Ratio for optimizing land use
- Land use and job mix, walkability

- Connectivity, intersections, block size
- Accessibility to facilities by streets, public transport, cycles and walk.

The mitigation and adaptation to climate change, disasters and risk management and the safety of women, old persons, children and other vulnerable sections of the society need a comprehensive approach in compliance to NDMA guidelines and Hyogo framework.



Source: IPCC, 2014

Fig. 7: Critical components of Sustainable Spatial Planning

a) Land, Zoning and Jobs

Land is a key resource for sustainability and should be used optimally. It should not put a large footprint, while providing space for jobs, infrastructure services and housing. A major focus area has to be local economic promotion and poverty reduction. A large number of the unemployed are forced to take on informal, illegal or uncertain jobs, and their entrepreneurial potential and development opportunities lie untapped. This needs rethinking the concept of land use zoning, whereby the work centres(zero polluting industries and commercial) can co-exist with residential use. At least 50% of the workers should be provided with their residences within a walkable distance from their workplace. At least 10 per cent of commercial and industrial areas may be reserved for the informal sector, including Janta markets, workshops, shops, small offices, kiosks, fruit and vegetable stalls, etc. Just 1 to 2 sm of space can create one livelihood for informal sector against 3 to 6 sm of space per formal shop. As such, by informal sector jobs and mixed land use, it is possible to expand access to livelihoods and reducing poverty.

Writing about home-based enterprises and hawkers in Delhi, Surbaya and Pretoria, Graham Tipple of the University of Newcastle upon Tyne, concludes that *"they should be accorded more attention by policy makers – not to control them, but to find ways of cooperating with entrepreneurs to assist them to be effective and efficient. Other reason why cities need vendors on streets and not designated food courts, is because hawkers are the eyes of the street and prevent violent crime. Our city roads are safer because of them."*

This implies that to establish closer links between shelter and poverty reduction, it is necessary to revise the concepts of land use zoning and building regulations. There is a need to rethink and review the planning paradigm and norms, such as land use, FAR and densities, which are equitous, compact and promote affordable housing. The densification can lead to travel reduction, economy of services and conservation of agricultural areas. Although there are objections to the idea of high-density planning, empirical data indicates correlation of urban density with less transport energy and car use. The compact and smart growth supports a high transit-share and makes walking and cycling attractive. The Indian cities have an overall density of 100 to 240 PPHa, which can be selectively doubled along public transit corridors, excluding the archaeological, heritage and conservation zones.

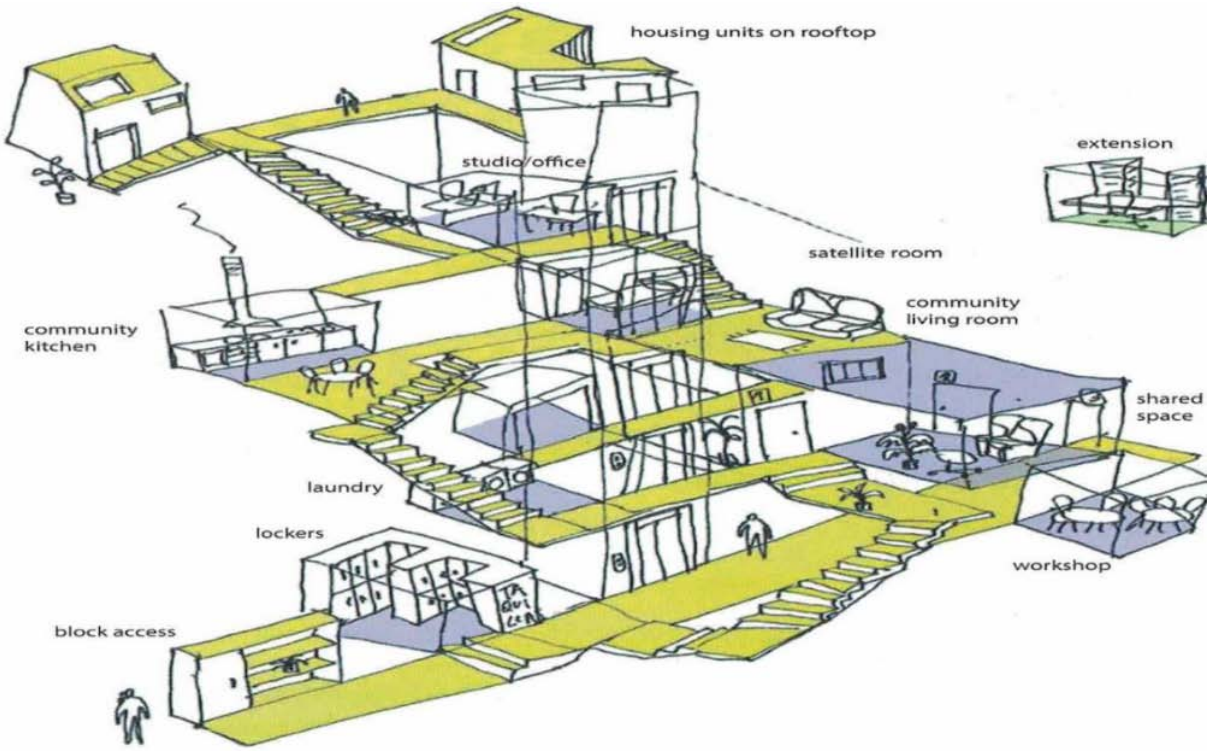
There is a simultaneous need for strengthening the services, greens and amenities. The private owners and developers can be made to provide part of their land/ built-up area for public greens and social facilities. While higher density and FAR, may reduce the cost of land per unit area, the cost of construction increases beyond the walk ups (15 m height), owing to lifts, foundation, fire sprinkler system, services, generator,

etc. There are also implications with respect to safety of women, elderly and children, home based occupations, community interaction and communications. As such, a pyramidical structure can be worked out in terms of height. For those at the base of the pyramid, the walk-ups, low rise –high density development patterns can be adopted. For the middle-income group people mid-rise (up to 12 storeys) and for those who are rich, high rise development can be encouraged.

The urban design and planning have to be open ended having flexible spaces for multiple cultures, synthesising universal values, local climate and technology. In hot climate the objective of site planning and building form is to minimize solar gain and to reduce the need of cooling, thus reducing the demand for energy. As such, it is necessary to adopt compact and dense forms with mixed uses. Landscaping can enhance the ecology and aesthetics and cool the buildings. Apart from ground planting, vertical landscaping, patios and roofs can be landscaped.

The parametric model can be a tool for redevelopment of brown fields, where large number of trees are existing. As a basic principle, no tree should be cut. The parametric model of allows for their conservation by adjustments in road alignment and building footprint as per site condition.

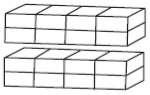
The service networks and transportation can also be parameterised to reduce their carbon footprint. Against the Data Model which deals with the performance of urban environment, the parametric model is crucial tool for integrated planning and smart built environment. As a pre-requisite, it is essential to computerise /digitise land records, allow formation of small cooperatives of the residents, and encourage the engagement of the professional groups and private sector to act as a catalyst and facilitate implementation of redevelopment schemes.



Source: NPR, (www.npr.org)

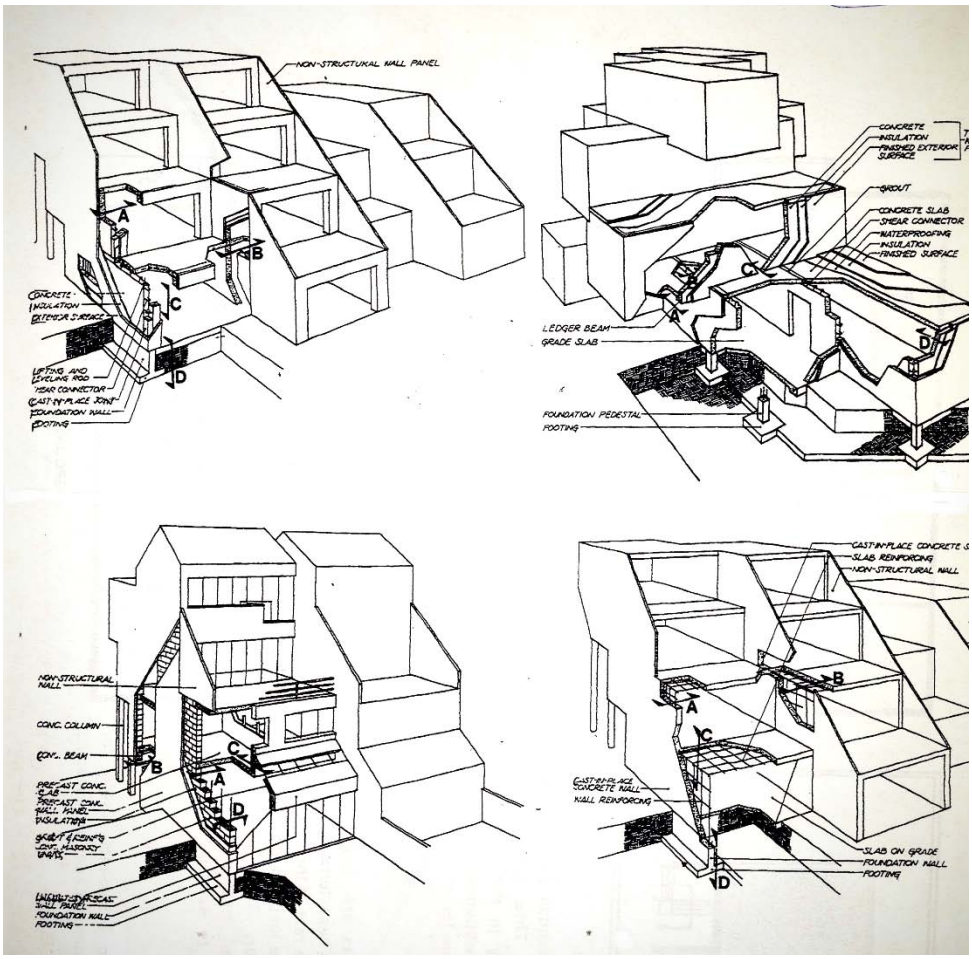
Fig. 8: Mixed Land Use for Work-Life Integration

The concentration of activities enables the reduction of energy consumption, optimization of land costs, while meeting the locational preferences of the occupants. The following figure indicates the options, so as to select the building form with minimum footprint and envelope without reducing the overall floor area.

Building form	 *8 separate houses (ground floor plus basement)*	 *2 terraces of 4 house} (ground floor plus basement)*	 *block of 8 flats (2 storeys plus basement)*
Site area	100 %	70 %	34%
Envelope surface area	100%	74 %	35%
Heating energy	100 %	89 %	68 %
Construction costs	100%	87%	58 %

Source: Presig H. R, et al (1999) Okologische Baukampetenz, Zurich

Fig. 9: Comparison of the surface area, energy consumed and construction costs for eight building unit in different configurations. The lower the footprint and envelope area, more energy efficient is the building.



Source: Community architect daily.blogspot.com

Fig. 10: High density -low rise housing options for Coldspring New Town: crisscross panel systems placed at right angles to one another, optimum conventional construction and large panel system (Architect Moshe Safdie)

Local climate has a significant connection to the energy use, climate resilience and urban heat island mitigation. For example, areas with cooler mean temperatures and more cloudy days would have less energy savings compared to the areas with reduced cloud cover and rain and higher temperatures. Also, the effect of wind in dispersing pollutants may improve the air quality. Trade–offs between roofing types and insulation are influenced by the local climate. Passive design strategies such as day-lighting and natural

ventilation, should be integrated with the design and construction. Some low energy passive techniques are given in Box 1.

Box 1: Some Low Energy Passive Techniques

Insulation

The heat-transfer through the building skin is reduced: the heat loss from the building is reduced in winter and heat penetrations is prevented in the summer

Mass

Mass stores heat to stablise room air temperature: for heating in winter, solar heat is absorbed in day time and released at night. For cooling in summer, mass is cooled at night time to keep rooms cool in the day time.

Air Lock

Air lock prevents the heat loss by air leakage to make the building air-tight.

Solar Glazing, Solar Passive Devices

The solar window or solar-collector uses solar heat positively.

Air-Circulation, Wind Related Orientation

Air is circulator to supply the heat and homogenize the air temperature distribution in the room.

Sun Space, Sky Courts, Atria

Sun spaces are attaches to the building in order to collect solar heat positivelty like greenhouses, conservatories, sun rooms, etc.

Shading, Sensor Controlled Fenestration

Solar insolation in the summer is blocked and heat penetration into the building is prevented.

Cross-Ventilation

Air ventilator lets fresh air in and exhausts hot room air out. Air movement promotes heat emission from the human body surface and gives a fresh feeling.

Night Flushing

Mass of cooled air in the night time is vented through the cuildfing to cool it. It is effective to store 'coolness'

Earth, Bio-Climatic Design

The stable temperature of the earth can be utilised for the purpose of heating and cooling. Earth berming on the room has the same effect.

Water Spray

Water sprayed on the building to promote evaporation, evaporation cooling is effective in dry climates.

Dehumidification

This expells the damped room air and/or intentionally condensed water. The building material which works as aspitator of humidity is also effective.

Top-Lighting

Light is introduced into the spaces at all seasons but solar control in necessary in summer.

Side-Lighting

High side-lighting is effective in distributing the illuminance homogeneously. Solar control is necessary depending on the window orientation.

Light Guide

Special devices transfer the light to the deep interior of the building.

Light Shelf

The shelf which is installed at the glazing reflects and diffuses the direct beam and the light can reach into the deep interior.

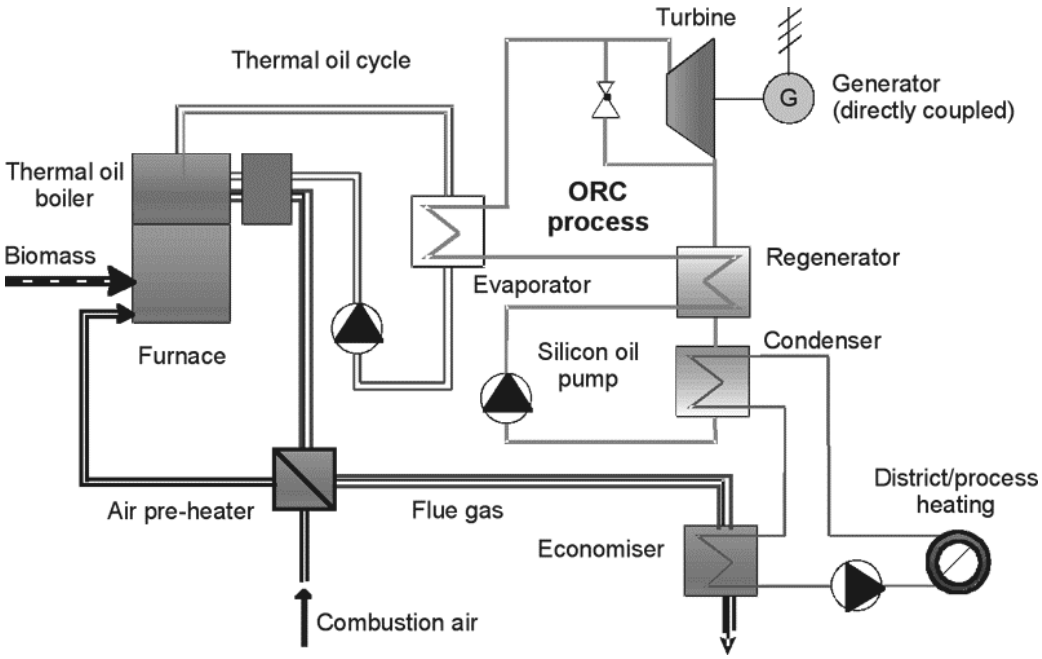
Source: PLEA (Passive and Low Energy Architecture, 1991) Process Architecture No. 98, Tokyo Japan

b) Smart Utilities and Services

Smart utilities aim at sustainable and renewable energy, water supply, drainage, sewerage, recycling and waste management. For water supply, the ICT solutions, such as SCADA system, enable enhanced efficiency. Similar benefits are available in respect of solid waste management and other utilities. RFID controlled three bins recycling, blockchains and micro-irrigation system can make the utilities efficient. Smart utilities can give energy saving up to 30%, reduce carbon emissions and provide higher efficiency and comfort. Information technology can be used for better services, high-speed communication and data management, carbon-emission accounting and performance objectives. The buildings can be designed as energy bio-reactors, urban nebulisers and detox towers. Innovative systems can convert bio-mass and noise into energy, conserve and recycle water and promote urban agriculture.

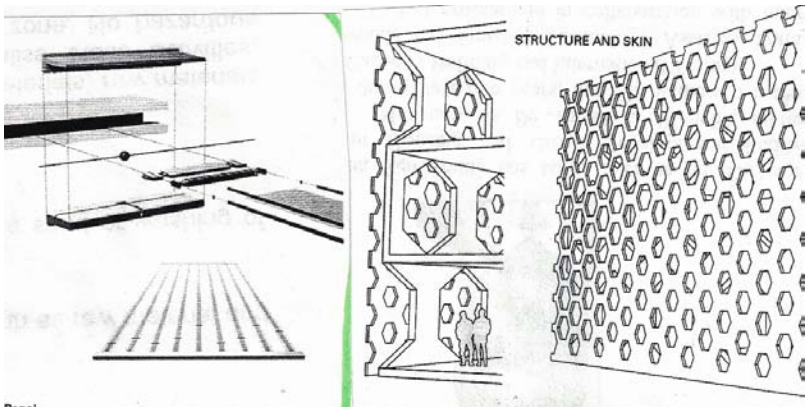
c) Building as an Energy Bioreactor

Noise and heat insulating panels, made of carbon fibre and cyanobacteria create a closed autonomous system of air circulation within a building, protecting it from outer pollution by providing fresh ionized oxygen. The exterior should be able to open and close. Within these modules, the cyanobacteria grow. The modules are filled with a special water solution that reacts with carbon dioxide to produce oxygen by photosynthesis process.



Source: David Constable, 2012, Trashscraper

Fig. 11: Gasification Process: Electricity from Bio-mass



Source: Ryan Browne, Nathaniel Dunn, Daniel Nelson & B. Scholten, Urban Transducer, and Amandine Quillent, F Zaini, Urban Coral Reef, in Evolo Skyscrapers, 2012

Fig. 12: Acoustic Panel and Urban Coral Reef Skin for Energy from Noise

d) Buildings as Respirational System

Buildings can be designed as huge air-purifiers, which transform the polluted air and exhaust fumes into clean air by water algae and sea sponge. These contain organisms that convert greenhouse gases and exhaust fumes into oxygen.

Urban Nebulizer is a device to aid breath for an asthmatic. It takes temperature inversion, smog and polluted air of atmosphere and diffuses it by smokestack, combined with water vapour. The structure can also function as a botanical garden, mostly with acicular trees for air purification.

Detox Tower: A building can double as a detox tower which cleans air through its outer skin and internal detox loop. The detox tube has three layers-the first is Voronoi/ aerodynamic adaptable structure, the next is a nano-hydrophobic membrane layer with venturi that uses lichen and algae for purification purposes. Finally, the air passes through layer three, which comprises a flexible aerogel. The building can be designed to give the chimney effect, which cools the air entering at its base and flows out at the top. The building skin can also collect solar energy.

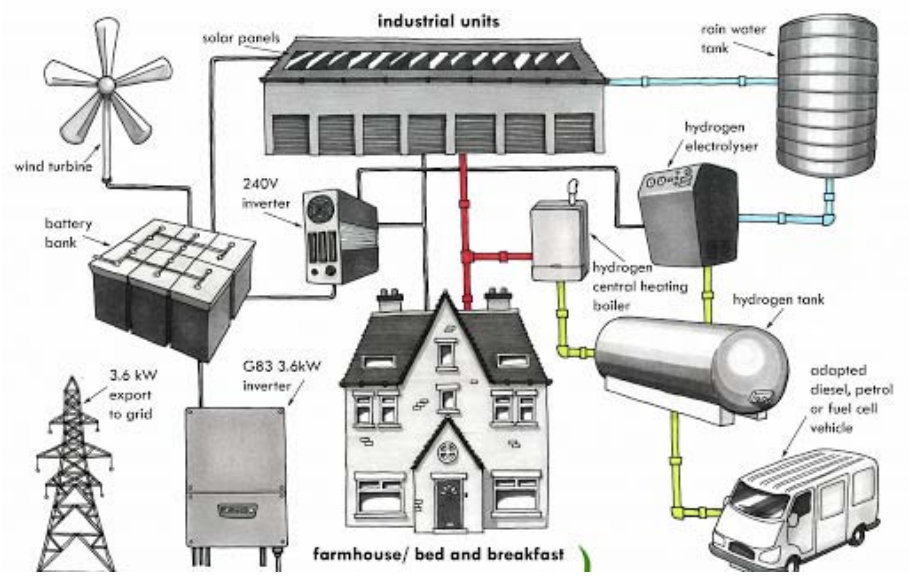


Fig. 13: Wind Turbines, Solar Parabolic and Microgrid

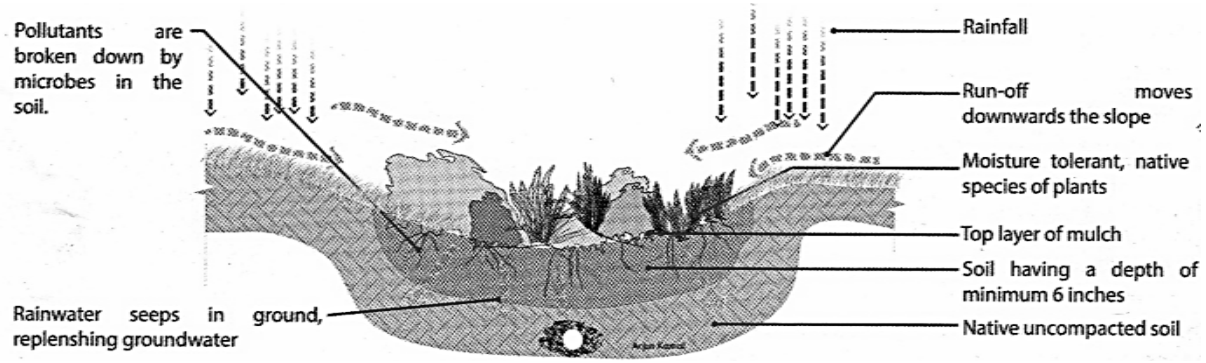
e) Converting Noise into Energy

The urban transducer captures airborne sound converting it into energy by using acoustic panels that perceive frequencies and wavelengths. The acoustic panels on the exterior of the building contain multiple bands with tuners which resonate at a specific frequency. They can slide to the desired locations, changing the band frequency. The bands change the magnetic field by electrostriction and transform noise into electrical current by a piezoelectric transducer. The urban transducer has ability to remember the frequencies and their locations. It can also be combined with the wind energy produced by miniature turbines. The acoustic panels that envelope urban transducer is made up of multiple metal bands with individual tuners and sensors that sense frequencies.

f) Water Conservation and Evo-transpiration

Grey water treatment by root zone system using urban forestry and nutrients can produce evaporation-transpiration. The irrigation system is 1 m below ground to reduce evaporation losses, pollution and to prevent odour. The vegetation cools the environment. An adult beech (Fagus Sylvatica) has a cooling power of 1,000 mega-joules per day. Each litre of water evaporated by a tree produces 2,300 kilo joules (0.64 kwh) of cooling. By proper design, we can use this energy to cool buildings, in addition restoring the nature. The plants species for cooling should be suitable for suction of particulate, evapo-transpiration and wastewater treatment.

Water reservoirs in the form of funnels, rain gardens, swales and reed fields serve as a hydro-botanic treatment unit. The rainfall stored in a reservoir and treated wastewater can be used for flushing toilets, washing machines, watering plants, cleaning floors and other domestic applications.



Source: Jain, A.K. (2015) The Idea of Green Building, Khanna Publishers, New Delhi.

Fig. 14: Bio-swale Captures Rainwater and Recharges Groundwater

g) Urban Agriculture

For urban agriculture multi-level platforms can be created along with micro-irrigation and humidifying mechanisms. Methanisation of organic wastes, air supply and photovoltaic systems provide supports to the idea of urban farming and artificial urban biotope. This can help in availability of organic produce locally, reduce haulage and wastage of agriculture produce and bring greenery in midst of concrete jungle.

h) Building Resources and Sustainable Construction

The idea of circular economy is based on the continuity of raw materials, products and waste streams in a closed circular loop. It involves an energy centered approach towards design, materials and construction. Adoption of circular models for the building design and construction requires formulating guidelines, calculating resources, labour and material flows, their environmental footprint and impact and lifetime scenarios. The basic approach of circular construction is zero emissions and wastes by on-site recycling to save the environment.

i) Construction and Demolition (C & D) Waste Recycling

Construction involves generation of construction and demolition wastes. These need to be disposed of and recycled as per the Construction and Demolition Waste Management Rules, 2016.Recycled products reduce the demand for new materials. Such materials include reused brick, steel, concrete, gypsum, sulphur, wood alternatives, reconstituted wood, straw, bamboo, wood waste pallets and panels for construction.

j) The Breathing and Green Facade

Facades are the building envelope forming the outer skin of a building and express its image and creative intent. They are also important environmental moderators. A thoughtfully designed skin can make a building work more effectively for its users and the environment. It can effectively control the physical environmental factors such as heat, light and sound, thus improving the occupant comfort within a building. The location and climate are crucial factors in selecting appropriate façade materials and deciding on design strategies for sustainable façade. As the materials of façade are exposed to mechanical, weather and maintenance, the use of high-performance materials such as titanium and high alloy special steel (ferrite austenite steel) assumes an economic and ecological relevance.

The breathing and green facade aims to create green spaces closer to the users. The openable windows allow fresh breeze and facade planting creates a microclimate, which is less prone to heat gain from solar radiation. Wind resistant plant scan also act as wind breakers. This idea has been pursued by the architectKen Yeang with his “green” facades, on the Menara Boustead Tower in Kuala Lumpur. The green wall and vertical garden with deciduous plants can reduce the solar gain inside the building, reduce the street noise and reduce energy load. It also produces a stack effect between the planted facade and the building exterior, channelling the heat away from the building. It has been designed keeping in view architectural and functional requirements, thermal performance, flexibility, HVAC system and maintenance costs.

Fig. 15: The Opus Business Bay, Dubai (UAE), Architect Zaha Hadid. Materials used for facade and fenestration include aluminium unitized curtain wall system, steel and aluminium skylight system, carbon fibre composite stick system curtain wall and high-performance mirror fritted and blue body tinted double curved glass. The glazing comprises complex 3-D forms especially manufactured for the facade.

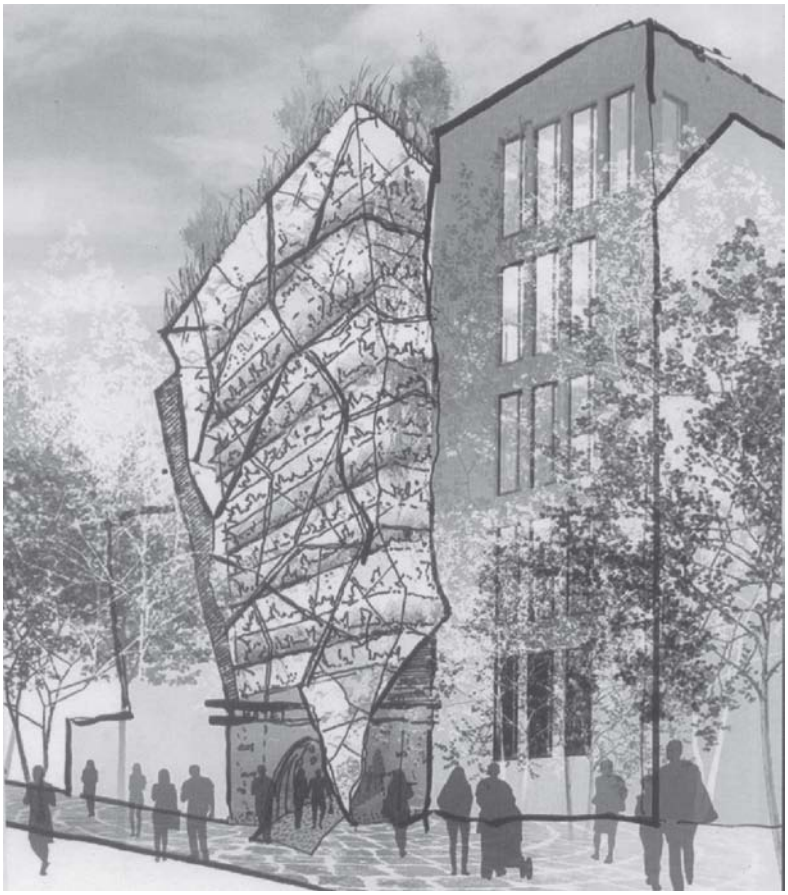


Fig. 16: Green facade of proposed Edible Hotel, London, Dexter Moren, Architects

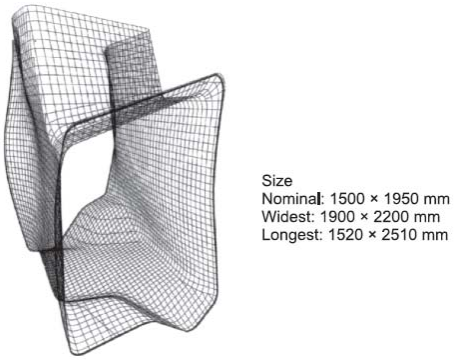
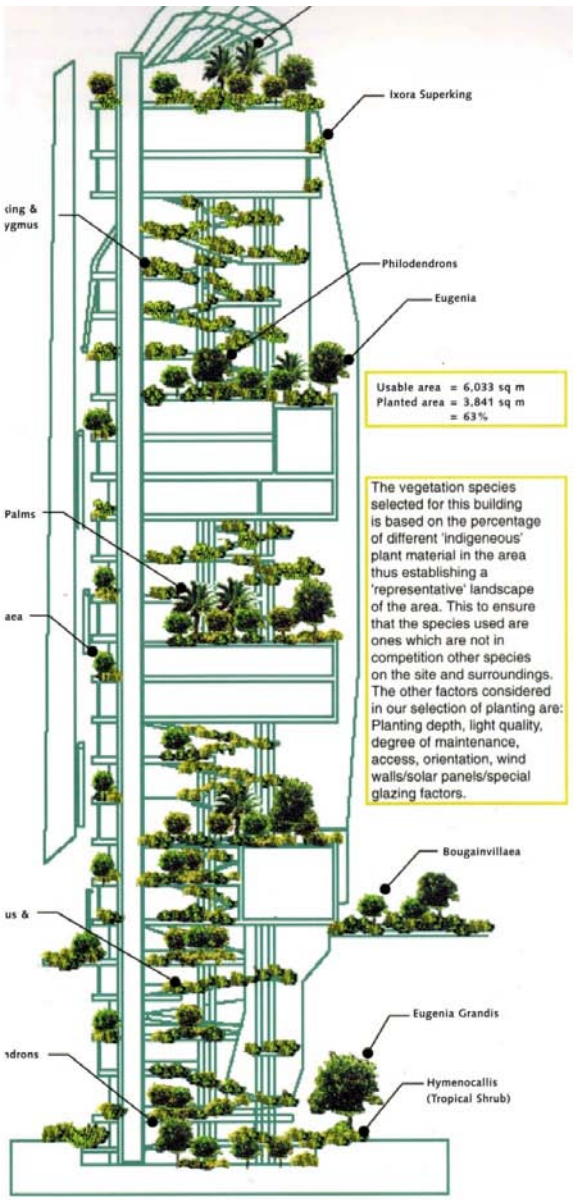
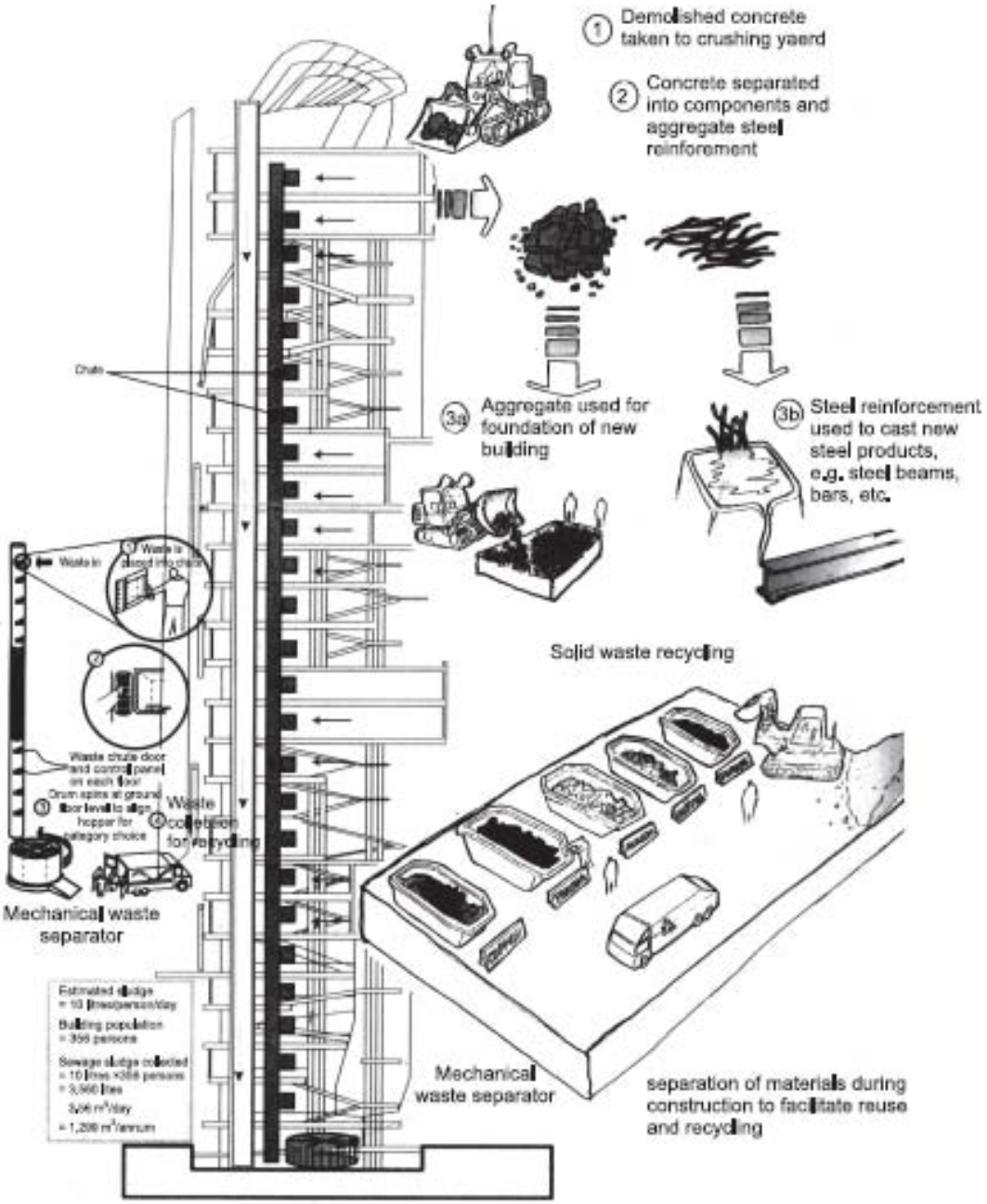


Fig. 17: Void surface quadrilateral modules are all unique in shape and size, Architect Zaha Hadid



Source: Yeang Kenneth (1999) The Green Skyscraper, the Basis for Designing Sustainable Intensive Buildings, Prestel , New York

Fig. 18: Bio-climatic skyscraper: Climate zone and precipitation determine the building design, its fabric and features. Vertical, spiral/ hanging gardens, terraces, courts, atriums, louvers, sun shades and shaded envelope are combined with bionic controls and intelligent systems. Architect Ken Yeang



Source: Hamzah TR and Yeang, Ken, Ecology of the Skyscraper (2001)

Fig. 19: Concrete recycling by Bawttle McCarthy, Consulting Engineers, Editt Tower, Singapore

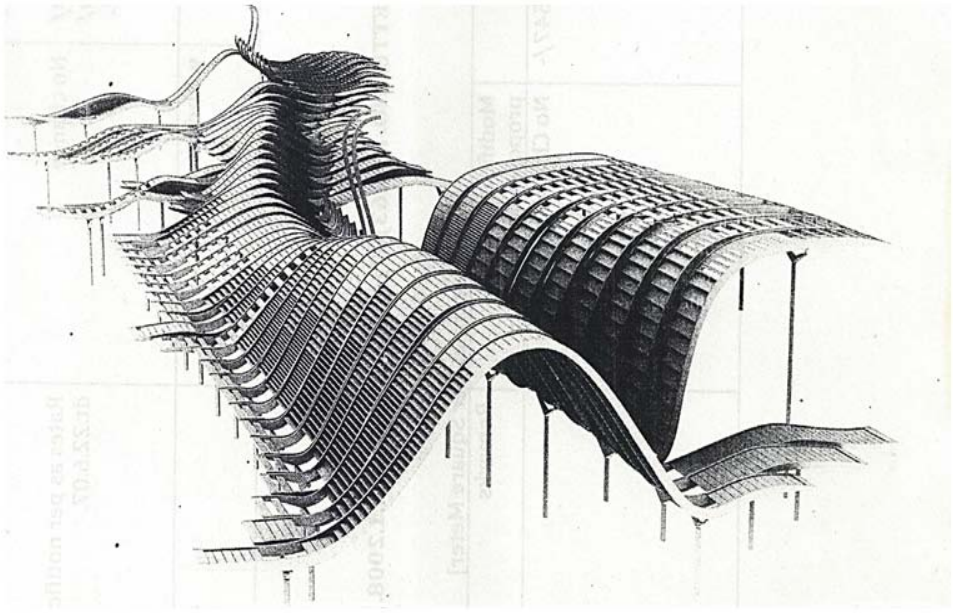


Fig. 20: The architecture, engineering and construction industry are increasingly operating within the physical and digital era of connectivity, that merge social, ecological and technological complexities

Source: Zaha Hadid Architects, Galaxy Soho, 2012

Fig. 21: Galaxy Soho

The heuristics of parametric urban design include the avoidance of rigid forms, functional stereotypes and segregated zoning. This implies the use of the intelligent information, rich deformation of soft forms, differentiation of all systems through gradients, thresholds and singularities and interdependent correlation of all systems. This produces a combination of complexity, rigor and elegance as manifested in the works of Peter Eisenman, Frank Gehry, Zaha Hadid, Rem Koolhaas, Wolf D. Prix, Bernard Tschumi, Daniel Libeskind and others.

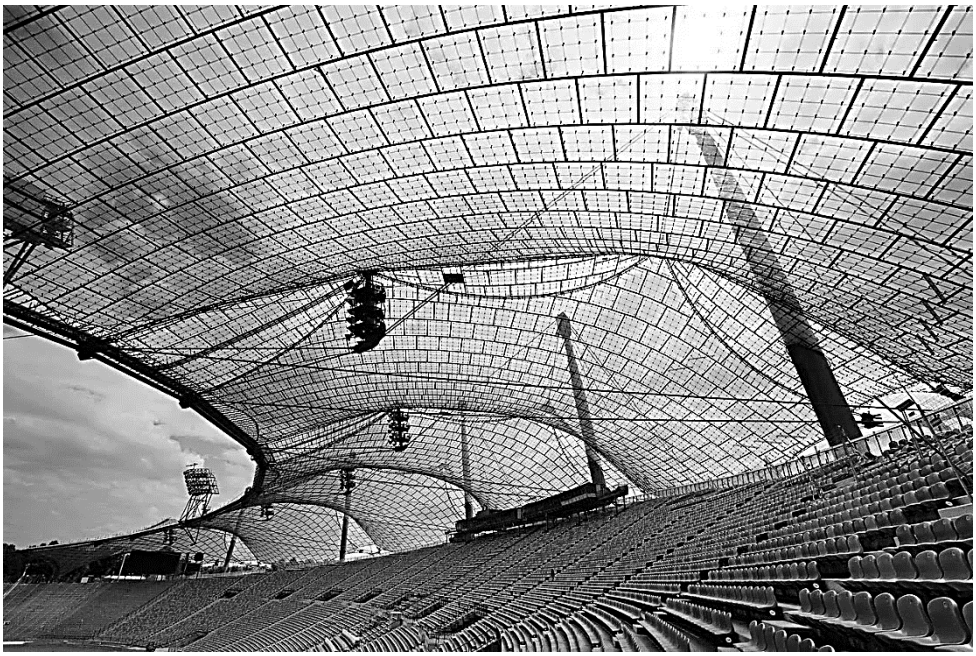


Fig. 22: Frei Paul Otto used lightweight tensile and membrane structures in the roof of the Olympic Stadium in Munich for the 1972 Summer Olympics

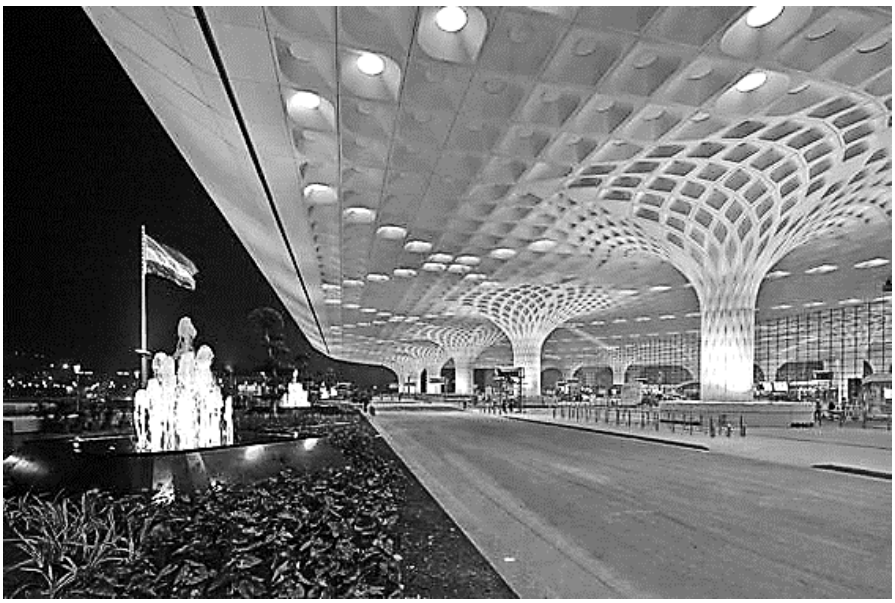


Fig. 23: Chhatrapati Shivaji International Airport Terminal 2 in Mumbai, India, designed by Skidmore Owings and Merrill (2014)

Chhatrapati Shivaji International Airport Terminal 2 in Mumbai, India, by Skidmore Owings and Merrill (2014)has been designed to accommodate traditional Indian departure and arrival ceremonies, and the complex variegated patterns.

Other projects, such as Google's California Headquarters by Bjarke Ingles (BIG) and Thomas Heatherwick, Beijing, New Airport Terminal Building in Beijing, China by Zaha Hadid Architects , Harbin Cultural Center in Harbin, Heilongjiang, China by MAD Studio, and Earthly Pond Service Center International Horticultural Exposition by HHD-FUN, canherald a new phase of parametric urbanism, digital architecture, andurban design.

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Career | Credibility | Exclusive | Reputation

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Fellows receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

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Career | Credibility | Reputation

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Career | Financial

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john [AT] globaljournals [DOT] org.

Career | Credibility | Reputation

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Access to all the premium tools

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Career | Credibility | Financial

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Early invitations to all the symposiums, seminars, conferences

All fellows receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

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Fellows can publish articles (limited) without any fees. Also, they can earn up to 60% of sales proceeds from the sale of reference/review books/literature/ publishing of research paper. The FSFRC member can decide its price and we can help in making the right decision.

Exclusive | Financial

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Financial

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ASSOCIATE OF SCIENCE FRONTIER RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

Benefit

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Exclusive | Financial

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Associate	Fellow	Research Group	Basic
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Certificate, LoR and Momento **2** discounted publishing/year **Gradation** of Research **10** research contacts/day **1 GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day **5 GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

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Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

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2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
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Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

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Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

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- Findings
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- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

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The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

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- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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