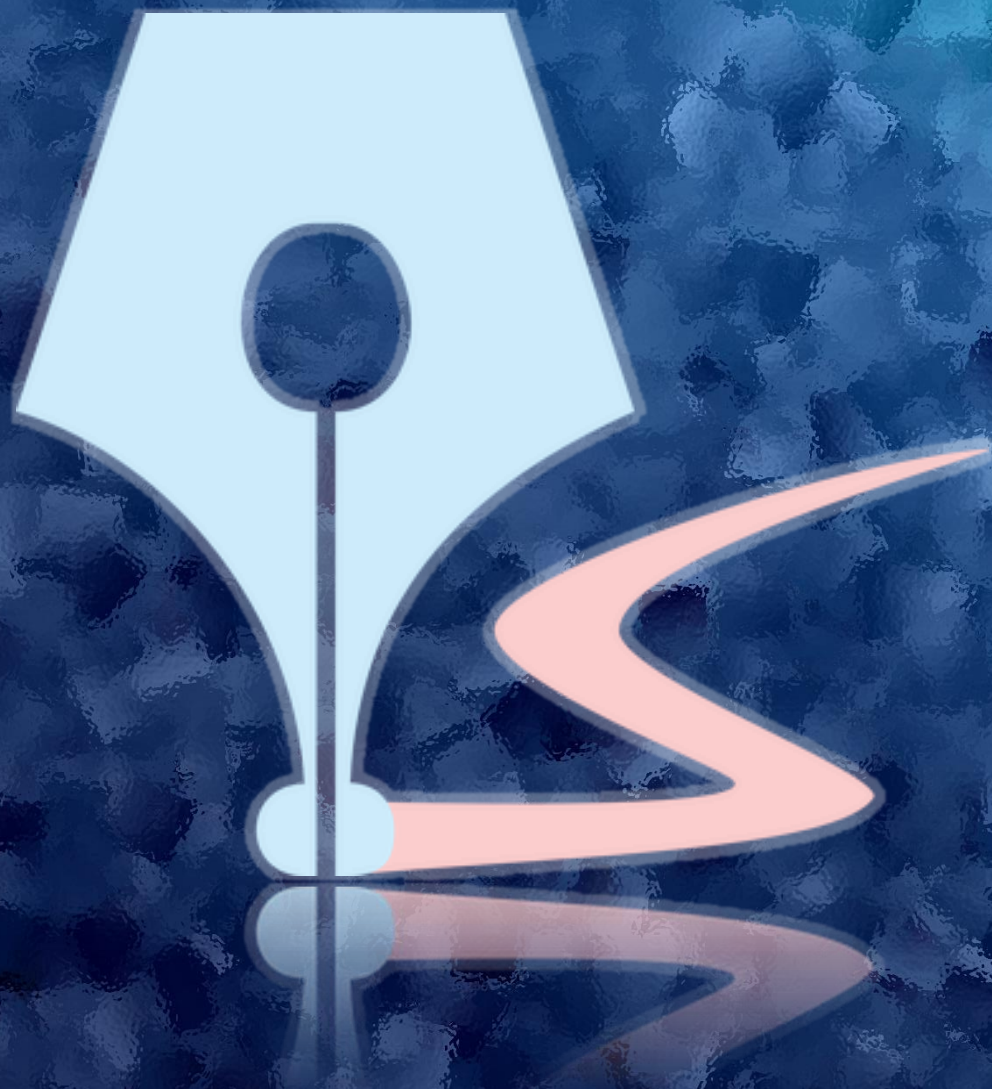


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A Brief Study on Different Biofuels

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Abstract:

The human inhabitant's explosion is the primary driver of today's mass extinction. The need of people in various aspects is so increasing for their survival. The use of fossil fuel is one of such needs to us. Though it is known burning of fossil fuels generally changes the global climate. Acceleration of global warming is now a day's an important aspect for discussion. It is proved scientifically that the emission of greenhouse gas from burning of fossil fuel is one of the main sources. So to supply the significant energy and to reduce air pollution, biofuels may be an alternative energy sources. The excessive use of fossil fuels results the lack of storage in underground earth then people naturally have to depend on biofuels. But the problem also arises there. At the same time increasing demand of the production of biofuels will put a huge burden on agriculture and food prices. Biofuels, generally attributed as liquid fuels are obtained from biomass. It comprises mainly wood, forestry products, agricultural crops and products, residues of animal wastes and aquatic plants. This can be made from vegetable oils also. Existing raw materials like agricultural residues or municipal garbage are the main sources for the production of biofuels. In this paper we travel around the different types of biofuels including biodiesel and their comparative study and also the production and use from an ecological perspective.

Key Words: *Biofuels; vegetable oil; biodiesel; Natural Gas; Biomass.*

Introduction:

Biofuels are derived from biological material, mainly from plants, microorganisms, animals and wastes [1]. Biomass is organic components are the source of alternative energy and all types of biofuels like solid, gaseous and liquid fuels that can be obtained from this biomass[2-4]. Solid biofuels are mainly wood, charcoal and fibrous matters. Fossil fuels such as wood and charcoal are extensively used as a primary fuel domiciliary purpose that is cooking. From sugar cane processing fibrous material is obtained and it is widely used for electrical power formation and preparation of steam [5]. Methane gas and producer gas are examples of gaseous biofuels and these are obtained subsequently from fermentation of animal wastes and from the pyrolysis [6] or gasification of wood and agricultural wastes. Liquid biofuels such as methanol, plant oils and the methyl esters are generally attributed as biodiesel [7]. Solid and liquid biofuels are used extensively as an energy inception because of their large prosperity, tremendous energy and low price. Coal and petroleum that is fossil fuel take million

of year to produce on the other hand biofuels are obtained very short time with appreciable yield. Although both are coming from bio materials [8].

Another important discussion comes how much we should use biofuels and fossil fuels because both are necessary in our daily life. The price of essential commodities including oil is soaring highly. In these circumstances biofuels can be most preferable alternative to fulfil the demand of human need using fuels in necessity. It takes the place of fossil fuels and the deteriorating fossil fuel then reserves. The result becomes as a way to mitigate the effects of climate change and to have a renewable, reliable source of energy. Biofuels are everlasting and renewable resource because they are continually replenished. Fossil fuels on the other hand are not perpetual and renewable, they drain out from our underground earth since they require millions of years to form [9]. So the burden comes to people to restore them for not having to face problematic situation due to lack of storage. It is blessing of science to have biofuel as an alternative. However, our viewpoint is to discuss the various types of biofuels and their comparative study for a better understanding to the general audiences to grow interest about this serious matter which may drive the future generation throughout the world.

Discussion:

Types of Biofuels

Primary biofuels are mainly fuel wood, wood chips and pellets, organic materials and are used generally for heating, cooking or electricity production in a crude appearance. Secondary biofuels which are obtained from cultured biomass and consist of liquid biofuels like ethanol and biodiesel that are extensively used in vehicles and industrial purpose.

There are mainly four types of biofuels. These are:

First generation biofuels:

First generation biofuels are biofuels which are on the market in substantial amounts today. The characteristic 1st-generation biofuels are sugarcane ethanol, starch-based or 'corn' ethanol, biodiesel and pure plant oil. The feedstock for producing 1st generation biofuels either consists of sugar, starch and oil bearing crops or animal fats that in most cases can also be used as food and feed or consists of food residues which were prepared from sugar, starch vegetable oil, or animal fats using usual technology like fermentation, distillation and trans esterification processes and these processes are well-settled scientifically though these processes have been used for hundreds of years in many uses, such as making alcohol. The most common and important first generation biofuels are given below [10].

1. Vegetable oil
2. Bio-alcohols (most commonly ethanol)
3. Bio-diesel

4. Bio-gas

5. Solid Bio-fuels

Like alcohol triglycerides of long chain fatty acids are attached to glycerol in vegetable oil [13]. Each triglyceride contains one glycerol and three long chain fatty acids. The method used to make biodiesel is called trans esterification [5,14] because it is a process of converting one type of ester into other.

Advantages of vegetable oil:

- Biodiesel conversion from this biomass is very easy.
- It is widely accessible
- It can often be used directly in diesel engines with little modification

Disadvantages of vegetable oil:

- It is a valuable feedstock.
- Use of unrefined oil can damage the engine through carbon deposition due to incomplete combustion.
- The replacement of old growth forest with oil palms increase carbon emission and consequently damages biodiversity.

Bio-alcohol i.e. ethanol is mainly obtained by fermentation of sugars and starches and butanol and propanol are formed as co-product. Ethanol is the most significant first generation biofuel which is well studied a renewable energy resource. Corn is the main source of the world's fuel ethanol and most of that corn comes from the United States [10]. The utilization of ethanol-blended fuels like E85 can reduce the net emissions of greenhouse gases by as much as 37.1%.

E10 (10% ethanol and 90% gasoline) ethanol-blended biofuels decreases greenhouse gases emission by up to 3.9%. The effects of ethanol come to results in an overall diminish in ozone formation, an important environmental alarm. It profits energy protection as it shifts the need for some foreign-produced oil to domestically-produced power sources. Ethanol burns more diffidently (more complete combustion). Ethanol reduces the quantity of high-octane additives. The fuel spills from ethanol are more simply biodegraded or diluted to non-toxic concentrations. Production of ethanol requires important energy and huge amounts of land. Fuels with more than 10% ethanol content are not well-matched with non E85-ready fuel scheme components and may cause corrosion of ferrous components. It can negatively affect electric fuel pumps by growing internal wear and undesirable spark generation. It is not compatible with capacitance fuel level gauging indicators. It may result in erroneous fuel quantity indications in vehicles that utilize the system.

Despite its comparatively high price as a food crop, soybean is still a most important feedstock for the manufacture of biofuel. In this case, rather than ethanol, soybean is used to produce biodiesel. Soybean is most likely the awful feedstock for biofuel production.



Biodiesel is very simple like the normal diesel fuel. Biodiesel is serene of mono alkyl esters of long chain fatty acids made from renewable lipid sources, such as vegetable oil or animal fats. It is comparatively less inflammable than the normal diesel. It is easy to use as a mixer with normal diesel fuel. Bio-diesel is biologically degradable and hence less hazardous for the environment. It does not contain sulphur which is mainly responsible for acid rain. Bio-diesel is suitable for catalytic convertor in many cases. The engines, in which bio-diesel is used as fuel, are generally long-lasting. Its refineries are relatively simpler and environmental-friendly. Biofuels are higher octane containing and lubricity scoring compounds than the uncontaminated petroleum-based diesel fuel. It can improve engine efficiency and operating life cycle of the machine.

Comparatively bio-diesel is more costly than the ordinary diesel fuel. It tends to trim down fuel economy. Bio-diesel is generally less appropriate for use in lower temperature. Bio-diesel cannot be transported through pipelines like normal diesel. It releases more nitrogen oxide during its combustion which may cause environmental pollution. There are only a few petrol stations which are offering biodiesel-fuel. It can merely be used in diesel-powered engines. Sometimes bio-diesel may be cause of flatten of internal fuel tubes of older vehicles to be defeated their lifelong qualities. It is more probable than the normal petroleum diesel to attract humidity.

Biogas is primarily used to produce electricity, and a very small number of projects produce bio-based compressed natural gas (CNG) to power natural gas vehicles. Methanogenesis is the process by which organic substrates are digested into methane in the absence of oxygen. Through a consortium of organisms, these organic substrates are hydrolyzed, fermented, and finally converted into biogas by methanogens. Biogas composition varies significantly depending on the substrate, but it is typically composed of 40%–65% methane, 30%–40% carbon dioxide (CO₂), and various impurities, including hydrogen sulfide (H₂S), ammonia, and siloxanes [15, 16]. Recent analyses have shown little to no H₂S (<5 ppm) present in biogas streams generated from agricultural residues (soybean residue, corn stover, miscanthus, and bagasse) [17]. Biogas produced from wastewater tends to have higher methane content (higher specific energy), while biogas produced in a landfill tends to have a higher percentage of CO₂ (lower specific energy).

The term “solid biofuel” can be a speck deceptive because many people connect biofuels with superior calming and chemical processes. In fact, biofuels can be any renewable, biological material used as fuel. From the definition, it becomes clear that things like wood, sawdust, leaves, and even dried animal dung all constitute biofuels.

Advantage:

Generally, biofuels have some positive effects to be discussed like these are expected to have large financial crash especially for local performer. Biofuel production opens new market opportunities

and helps to expand agricultural products and thus new income showers on farmers enlarging the socio-economic condition. Consequently, in future agriculture will play a great role both in food production and also in energy provision. The increased feedstock production is expected to strongly contribute to the multi-functionality of the agricultural sector. Nevertheless, it is difficult to assess the real dimension of additional employment in production centre relating biomass and impact on local economy in the biomass sector. It is significant for ethanol dispensation than for manufacture of pure plant oil and biodiesel. This benefit for lipid derived fuels is particularly vital for small scale agricultural producer and SME's (small and medium-sized enterprises) [18].

Another advantage comes in the fermentation of sugar and starch-bearing plants, co-products as necessary supplement are produced in large quantities. Necessary supplements such as fodder, fertilizer, heat fuel, industrial raw material or as substrate for biogas plants can be used. An excellent example how co-products from ethanol production can be used is the bagasse, the fibrous residuals of sugar cane after pressing. In Brazil, bagasse is burned and the heat is used for the distillation process and for electricity generation. It's a good exemplification of biofuels advantage. Similarly, biodiesel and PPO known as lipid derived fuels are received in a lagged number. For instance, press cake from rapeseed oil extraction is a high value and protein enriched fodder. In biodiesel production glycerine is a valuable, usable co-product for industrial purposes [8].

Limitations:

The main source of first generation biofuels is the feedstock. The major component of feedstock is food crops such as corn and sugar beet. They create a hazard to food prices since the biomass are used for biofuels preparation. Prices for food and animal feeds which are the first generation biofuels have been increased due to several factors [19-22].

- More use of biofuels places a depressing contact on biodiversity and competition for water in some regions.
- Biomass for first generation biofuels requires lots of land to cultivate, and this provides only limited greenhouse gases fall.
- They also provide a small profit over fossil fuels in regards to greenhouse gases since they still require high amounts of energy to develop, accumulate, and procedure. Current production practice use fossil fuels for power.
- First generation biofuels are also a more costly alternative than gasoline, making it reasonably poor.
- Finally, biodiesel almost always comes from used oils from restaurant, as different to virgin oils, so the supply is limited by restaurants' oil utilize.

Second generation bio-fuels:

Second generation biofuels are the more developed industrial edition than that of first generation types, we can say that they're characteristically not imitative from food crops but this fuels are also produced from sustainable feedstock like first-generation fuels. Basically, these types of feedstocks are not generally used for human utilization. That is, second-generation feedstock does not come to use of human beings. Though it is a food crop but they are no longer useful for consumption. Second-generation biofuels are known as "advanced biofuels." because extraction of fuels from this source is very difficult. non-food feedstocks sources of biomass for 2nd generation biofuels include wood, agricultural residues, organic waste, food waste and specific biomass crops together with cellulosic, hemicelluloses or lignin [1]. This biofuels can either be blended with petroleum-based fuels combusted in existing internal combustion engines, and spread through existing infrastructure or is dedicated for the use in slightly adapted vehicles with internal combustion engines (e.g. vehicles for DME)[23]. This species holds plants together to formulate fuel. BTL-diesel (Biomass-to-liquids) and lignocelluloses ethanol [24] are the main sources in second-generation biofuel. Well known second generation Fischer-Tropsch fuels [25] are obtained by a group of chemical reactions that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons. It was first envisaged by Franz Fischer and Hans Tropsch. Lignocellulos's process refers to plant waterless material that is forest material (biomass) [26A ,26B]. It is obtainable in large quantities raw material on the Earth for the production of biofuels, mainly bio-ethanol. It is composed of carbohydrate polymers (cellulose, hemicelluloses), and an aromatic polymer (lignin)[27]. Poplar trees are required to undergo a pre-treatment process, and a series of chemical reactions that crash lignin. Lignin is the ingredient of the cell walls of all dry earth plant. It is the second rich natural polymer in the world, surpass only by cellulose [28]. Lignin is the only polymer that is not collected of carbohydrate (sugar) monomers. Lignin is an aromatic functionality and unique in that sense it is the only large-scale biomass source for 2nd generation. It is collected of up to three different phenyl propane monomers depending on the species. Thermochemical or biochemical reactions which are the initial steps that unlock the sugars surrounded in fibres of the plant [29]. After the completion of the reaction, plant ethanol is obtained which is resembles that of 1st generation ethanol manufacture.

Furthermore, another second-generation biofuel is bio-SNG, a synthetic gas similar to natural gas [30]. Straw and other plant residue produces synthetic gas involving a several thermochemical stage. Synthetic gas is a mixture of carbon monoxide, hydrogen and other hydrocarbons [31]. Hydrogen is used as a fuel and the other hydrocarbons are used as for the production of gas oil. The Scheme 2 shows how 2nd generation biofuels are obtained.

Main types of second-generation biofuels:

a) Waste vegetable oil: Waste vegetable oil has no food value and it may help to reduce the environmental pollution. Some diesel engines are designed in such a way that the obtained biofuels from this biomass is used directly without blending or refining [32].

Advantages:

- a) It doesn't release sulphur in the environment.
- b) Since it is a used product and it doesn't perturb the arable crops.
- c) Besides, it costs nothing in use of land.

Disadvantages:

- a) This biomass can damage to diesel engines if it is not accurately purified before use.
- b) It is difficult to collect because it is located in many points.

b) Grasses: Grass cultivation mainly depends on location. For example, Southeast Asia uses Myscanthus, whereas United States uses Switch grass.

Advantages:

- a) This grass needs to be planted only once, because it is permanent.
- b) This biomass grows on marginal land very quickly and yields of crops are obtained in a number of times a year [33].
- c) Less fertilizer is required for cultivation.
- d) This grass is used instantly without further processing as biomass.

Disadvantages:

- a) The use of direct biomass sometimes comes good and then grasses turning into biodiesel are not favourable.
- b) The process to turn grasses into alcohol is also complicated than others.
- c) While they're easy to plant, their seedlings should be constantly secured from the much stronger species of weeds naturally grown around them.
- d) Substantial humidity levels largely suit in their growing and they can't grow on arid soils.
- e) None can make Crops to be dense enough within the first few year [34].

c) Seed crops: This biomass can be cultivated on the marginal land in a considerable amount but energy value of biofuels is very much less than the biofuels from soybeans biomass. Another difficulties has been achieved in growing such crops on farmland and that's why its popularity has been reduced in a substantial amount.

d) Municipal waste: Now days this type of biomass is used for production of biofuels. It comprises all kinds of solid waste matter comes from human waste, grass, leaf clippings, landfill gas, etc.

The following fuels are obtained from the second-generation biofuels:

1. **Cellulosic Ethanol:** It is obtained via fermentation of sugars derived from the cellulose and hemicelluloses fractions of lignocellulosic biomass.
2. **Biobutanol:** It is prepared in a process like to ethanol but with different microorganisms. Presently the fuel yield is lower than that of ethanol, but biobutanol can be used as a call on replacement for gasoline without blending
3. **Biomass to Liquids (BtL) technology:** It is started to prepare with a synthesis gas (syngas) followed by Fischer-Tropsch process to gasoline, diesel, and jet fuel.
4. **Alcohol:** Methanol, Dimethyl Ether (DME) and mixed alcohols can also be prepared from syngas via catalytic synthesis. Alcohols are also obtained by fermentation of syngas by some specialized microorganisms [35].
5. **Biosynthetic Natural Gas (BioSNG):** Any way renewable natural gas can also be obtained via gasification and then followed by catalytic methanation and purification. Biogas can be made by an anaerobic digestion with microorganisms. This gas is composed of mainly methane and carbon dioxide. It can then be used as compressed natural gas (CNG) or liquefied natural gas (LNG) in vehicles or injected into the existing natural gas cylinder [36].
6. **Hydrotreated Vegetable Oil:** It is a used as a diesel substitute that has very popular fuel properties like high cetane, non-aromatic and does not contain sulfur [37].
7. **Pyrolysis Oils (known as biocrude):** This is obtained by ash pyrolysis (rapid heating to about 1,000°F followed by rapid cooling). Refining and upgrading generate liquid fuels for transportation or stationary applications (boilers, turbines) [38].

Advantages:

The profit of second-generation biofuels is various and 2nd generation biofuels are to be better to 1st generation biofuels due to following reasons [39].

- They use a non-food feedstock (like lignocellulosic biomass materiel, such as earth crops residues, forest products residues, or fast-growing devoted energy crops). So, the second generation biofuels are different from first generation biofuels because they don't come directly from food crops like corn and soybean.
- The fuel is a call on replacement for conventional petroleum-based fuels, meaning there are no limits on blending, or they can be used as is (without blending) in existing vehicles.
- Second generation biofuels are more environmentally friendly and produces less greenhouse gases.

- They do not produce co-products like animal feeds.
- Less requirements of land are applicable here so the competition for land with other agriculture fields come to lessen, food fiber and water are also less required.

Disadvantages:

- Second generation fuels are not yet produced on commercial scale. Due to high production costs and this process is not proven technically.
- Current harvesting, storage and transport systems are in adequate for processing and distribution biomass in large scales.
- A requirement of clear and long-term policy frame work is to ensure that industry and financiers can endow with assurance.
- Agricultural/forestry sector alters need to supply biomass feed stock from residues and crops imply a significant transfer in the current business model and as well as trade of feedstock and biofuel.
- The most favourable approaches and locations for 2nd generation facilities should be recognized that maximum GHG reductions while minimising cost and impacts on the environment and other agricultural markets. So the use of these fuels associated with less concern leading to food crisis in developing countries, or harmfully affecting consumer prices in developed nations.

Comparison between 1st and 2nd generation biofuels:

1st and 2nd generation biofuels may be submerged then second generation biofuels address many issues linked with 1st generation biofuels. They don't race between fuels and food crops since they come from distinct biomass. Second generation biofuels also generate higher energy yields per acre than 1st generation fuels. They allow for use of inferior quality land where food crops may not get proper support to grow. The technology is fairly immature, so it still has prospective of cost reductions and increased production efficiency as scientific advances take place surprisingly. However, some biomasses for second-generation biofuels still compete with land use since some of the biomass grows in the same climate as food crops. This leaves farmers and policy makers with the hard decision of which crop to grow. Cellulosic sources that grow alongside food crops could be used for biomass, such as corn stover (leaves, stalk, and stem of corn). However, this would deduct too many nutrients from the soil and would need to be replenished through fertilizer. In addition, the process to produce 2nd generation fuels is more elaborate than 1st generation biofuels because it requires retreating the biomass to release the trapped sugars. This requires more energy and materials.

The great advantage of these fuels is the vast range of feedstock that can be used for biofuel production, as well as the compact feedstock (e.g cellulose crops) costs. By using a holistic

approach, biofuels offer large economic advantages over fossil fuels, but direct cost comparisons are difficult. Negative externalities associated with fossil fuels tend to be feebly quantified, such as military expenditures and costs for health and environment. However, biofuels have the potential to generate many positive externalities, such as reduced greenhouse gas emissions, decreased air pollution, and job creation. At the same time biofuels decrease dependency from crude oil imports. As a result biofuels are more socially and environmentally desirable, usable liquid fuel, a fact that is often ignored in direct-cost calculations. Therefore, biofuels often seem uncompetitive although a biofuel market may actually provide long-term economic benefits when comparing environmental and social costs [40].

Third generation biofuels:

Algae fuel [11,12] or algae is the main source of third generation biofuels. It produces more than 30 times energy per acre than the land crops such as soybeans. Normally, algae are a various group of prokaryotic and eukaryotic organisms [41]. Algae can be classified either autotrophic or heterotrophic. For the growth of autotrophic algae, the following inorganic compounds such as CO₂, salts, and a light energy source are necessary. While the heterotrophs are non-photosynthetic that requires an external source of organic compounds such as nutrients as energy source [42]. Microalgae are very little in size and typically measured in a scale of micrometers. This species is generally grown at faster rate in water bodies or ponds and contains more lipids than macroalgae [43]. In case of algae the main advantage is the short harvesting cycle whereas for usual crops having harvesting cycle of once or twice in a year. Therefore, the foremost attention has been carried out on algal biomass for its relevance in biofuel area. The algae may be changed into different types of renewable biofuels and this can be categorized into three different ways [44]. However, biodiesel is obtained from diverse renewable lipid feedstocks and biomass. Monoalkyl esters of long chain fatty acids [fatty acid methyl esters (FAME)], i.e biodiesel may be used directly in various diesel engines [45].

The list of fuels that can be derived from algae includes:

- Biodiesel
- Butanol
- Gasoline
- Methane
- Ethanol
- Vegetable Oil
- Jet Fuel

Algae can be cultivated in a various method and it can be developed in any of the following ways.

a) Open ponds – This is the simple way in which algae is developed in the open-air ponds. Algae can be harvested simply and have low assets costs, but are less proficient than other systems. Other organisms can contaminate the pond so they are much concern even if from potentially damage having a fear to kill the algae

b) Closed-loop systems – This system is similar to open ponds, but it is not uncovered to the atmosphere and uses a sterile supply of carbon dioxide. It has large potential because it may be directly linked to carbon dioxide released into the atmosphere in every use.

c) Photo bioreactors – These are the most advanced and thus most difficult systems to implement, that comes with result in high capital costs. Their advantages in terms of yield and control, however, are unequaled. They are clogged systems [46].

Advantages:

(a) It has the capability to grow throughout the year; therefore, algal oil productivity is higher in touch relationship to the usual oil seed crops;

(b) There is a higher acceptance to high carbon dioxide content;

(c) The consumption rate of water is very a lesser amount of in algae cultivation;

(d) Necessity of herbicides or pesticides in algal farming is not needed;

(e) The expansion potential of algal species is very high in comparison to others;

(f) Different sources of wastewater containing nutrients like nitrogen and phosphorus can be utilized time to time for algal cultivation apart from providing any additional nutrient;

(g) It has the capability to grow under insensitive conditions like saline, brackish water, coastal seawater, which does not affect any conventional agriculture in producing [47].

h) They are biodegradable, so very naturally and comparatively safe to the environment if spill is one benefit of many biofuels over most of the other fuel types. Third generation biofuels are also called superior biofuels.

i) In algal biofuels like low land requirement for biomass production and high oil content with high productivity has been considered as the best resource, which can substitute the liquid petroleum fuel.

j) The high yield per acre (up to 10 times higher than with other biofuels), and the fact that algae do not compete for land or potable water with agriculture or forestry, as non-arable lands and non-potable water can be used are regarded as the two key advantages of algal biofuels.

k) One of the major benefits of algae is that they can use a diverse array of carbon sources. Most notably, algae might be tied straight to carbon emitting sources (power plants, industry, etc.) where they could directly switch emissions into usable fuel has been suggested. This means that no carbon



dioxide would be released from these settings and thus total emissions would be cut down considerably.

Disadvantages:

- a) The higher agriculture development cost as compared to traditional crops.
- b) High energy input is required for harvesting of algae and it is approximately about 20–30% of the whole cost of manufacture.
- c) Several techniques such as centrifugation, flocculation, floatation, sedimentation, and filtration are generally used for harvesting and concentrating the algal biomass [48].
- d) Although algae's are grown in waste water, need large amounts of water, nitrogen and phosphorus to cultivate.

Comparison between 2nd and 3rd generation biofuels:

Third generation biofuels are comparatively more energy intense than 1st and 2nd generation biofuels per area of harvest. They are cultured as low-cost, high-energy, and completely renewable sources of energy very resourceful to us. Algae are profitable in that it can grow in areas unsuitable for 1st and 2nd generation crops, which would lessen strain on using water and arable land used. It can be easily grown using sewage, wastewater, and saltwater, such as oceans or salt lakes. Due to this, a need to use water that would otherwise be used for human consumption is not necessary. However, further research still needs to be executed to further the removal process in order to make it financially competitive to petro diesel and other petroleum-based fuels. For an economic process in comparison to others, a cost-effective and energy efficient harvesting methods are required with low energy input. To Producing low-cost micro algal biofuels needs better biomass harvesting methods, high biomass production with high oil productivity through genetic modification, which will be the future of algal biology. Therefore, the standard algal harvesting technique in use, bio-refinery concept, advances in photo bioreactor design and other downstream technologies will further reduce the cost of algal biofuel production, which will surely be a competitive resource in the near future. The capital and operating expense of third-generation production are so high. So some sub-sectors are required for additional research and development to reach the level of being a sustainable process of consistent biofuel construction on an industrial scale, but the potential is highly talented [49].

Fourth generation biofuels:

Fourth generation biofuels will be based on raw materials that are essentially inexhaustible, cheap and widely available [1]. This type of biofuel depends on the conversion of vegoil and biodiesel into gasoline [10].

Advantages:

Fourth generation biofuels are more superior than third because these algae are obtained with elevated yield and along with high lipid contain. It has more CO₂ capture capability and high manufacture rate than other biofuels.

Disadvantages:

The major disadvantage of algae production is involved the high rate of initial investment. Research for algae production is now at its preliminary stage. The fourth-generation biofuel research has been started from 2006 and significant result has not been published yet in peer-review journals.[50]

Conclusion:

First generation biofuels illustrate a step toward cleaner, renewable energy, but they lag behind gasoline due to energy density and economic factors. They also present an ethical dilemma moral dis-adjustment with regards to use of food crops, as there are millions of people starving and affliction causing by situation around the world. This is mainly to the point in countries with large populations where corn grown-up such as China, Brazil and Mexico (the 2nd, 3rd and 4th largest producers of corn, 1st, 5th and 11th largest country populations, respectively). Some benefits are also provided from second generation biofuels but the biomass requires adaptable steps and competes with food crops over arable land in some parts of the world. Third generation biofuels represent the most hope, but plenty of research still needs to be done to cut down production costs and make this type of fuel production commercially, economically practicable.

A renewable resource of energy it is having limitations and their technological progress refers good and bad effects. 1st generation biofuels lag behind as they come from biomass that is also a food source in world. This causes a problem when there is not enough food to feed everyone. 2nd generation biofuels come from non-food biomass, but still compete with food production for land use. Finally, 3rd generation biofuels present the best possibility to get an opportunity for alternative fuel because they don't compete relating with food. However, there are still some challenges in presenting them economically viable.

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Socio-economic analysis on selected bridges in Kolkata, West Bengal – An insight through Exploratory Factor Analysis & Garrett Ranking

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Abstract:

Economists are of the opinion that infrastructure is the backbone of each and every economy. Facts & figures clearly shows that given a choice, investors prefer to invest their money in countries whose infrastructure is comparatively developed. Therefore, it can be said that rapid infrastructure development is one of the most basic ways in which a country can take advantage of various economic opportunities. It is, therefore, no surprise that countries around the world focus heavily on building infrastructure. The present study has been done on four heritage bridges in Kolkata i.e. the Howrah Bridge, the Vivekananda Setu, the Vidyasagar Setu & the Nivedita Setu & it has been sub-divided into various sub-sections based on a structured questionnaire. The present research will try to evaluate the socio-economic improvements by looking at opportunities for economic productivity, socio-economic capability to enhance a sustainable and healthy life and equal economic distribution. The tools used here mainly are Exploratory Factor Analysis using Principal Component Analysis with Varimax Method of rotation & Garrett Ranking as a part of qualitative research.

Key Words: *Economic productivity, Structured questionnaire, Exploratory Factor Analysis, Principal Component Analysis & Garrett Ranking etc.*

JEL Classification: -H51, H52, H53, H54

I. Introduction

Developing countries like India have also taken up this sentiment as they have also announced plans to spend billions of dollars in order to build and upgrade their infrastructure to cope up with the world. Hence, it can be said that infrastructure and its financing is a vital issue all over the world regardless of whether the nation is developing or developed. Since infrastructure is such a high priority issue in the whole world, the financing of infrastructure projects is also considered to be a very major issue. As a result, an entire subject called infrastructure financing has been developed.

II. Brief Review of Literatures

According to the article written by **Tan and Yao (2006)**, the objectives of re-settlement were formulated with the idea that somebody need to go out, need to be stable and then getting wealthier gradually (Tan & Yao 2006:352). The key word indicates that the socio-economic development is a slow process and for that patience is needed and it does not come fast. Many scholars have evaluated

the effects of hydropower projects within the first 10 years after relocation, focusing on relocated people's livelihood development.

Socio-economic development within this research is perceived as being contrary to poverty. **Wang et. al. (2011)** state that there is a shift from "the standard of objective, well-being and absolute poverty to that of subjective well-being and relative deprivation" (Wang et. al. 2011:716). Poverty can be verified & analyzed in absolute terms or in terms of relativity; while the term **absolute poverty** is measured in terms of specific benchmark, relative poverty is measured in terms of social standards (White 2008:25) and therefore it is contextual. This research agrees with contextually in determining socio-economic development.

White (2008) in his study, states that there is a shift to qualitative and multi-dimensional approaches within the discourse of development and includes certain aspects of life such as material consumption, health, education, social life, environmental quality, spiritual and political freedom (**White 2008:25**). White argues that a comprehensive understanding of socio-economic development should include a definition that takes contextual consumption expenditure and price differences into consideration, (**White 2008:27**) This research believes that **Jaffae, (1998)** a prominent scholar within socio-economic theory, provides more or less a same definition of socio-economic development;

Jaffee (1998) in his study states that ability to produce an adequate and growing supply of goods and services productively and efficiently, to accumulate capital, and to distribute the fruits of production in a relatively equitable manner.

III. Identification of the Research Gap

A minute study of the available literatures reveals that, although many studies have been carried out on the concept of infrastructure financing, justification and factors determining the success of PPP in infrastructures in different parts of the world, **very few studies have thrown light on the Socio-Economic impact which will show the perception of the users using those infrastructures and apparently no study has yet been carried out on the perception of the users and/or the people residing in nearby areas of those bridges.**

Keeping in view the present scenario as well as the past one, the present research will try to evaluate **the socio-economic development in the four select Bridges by looking at opportunities for economical productivity, socio-economical capability to enhance a sustainable and healthy life and equal economic distribution.**

IV. Objectives of the study

- To highlight on the social as well as sociological impact of the selected infrastructures in Kolkata.
- To focus on the economic impact of the select infrastructure.

V. Research Methodology

The data collected for the study is primary in nature. The data has been collected with the help of a structured questionnaire. Random Sampling method has been used to select the respondents before interviewing.

At first a pilot survey has been conducted here within 30 respondents to gather a basic knowledge about the customers' perception regarding the selected bridges. Then on the basis of the factors

identified a structured questionnaire in 5-point Likert scale has been prepared to conduct the market survey **amongst 520 respondents (130 respondents from each bridge)**. The Bridge is chosen on Judgemental Sampling Basis amongst the prominent bridges in Kolkata and its surroundings. Appropriate statistical tools and techniques including descriptive statistics, Exploratory Factor Analysis using Principal Component Analysis with Varimax Method of rotation & Garrett Ranking as a part of qualitative research was used depending on the nature of data.

VI. Results & Discussions

Results of the KMO & Barlett's Test

Table 1.: KMO and Bartlett's Test		Howrah Bridge	Vivekananda Setu	Vidyasagar Setu	Nivedita Setu
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.839	.740	.832	.792
Bartlett's Test of Sphericity	Approx. Chi-Square	624.940	822.568	619.867	742.161
	df	210	210	210	210
	Sig.	.000	.000	.000	.000
(Source: Author's own Tabulation)					

The value of KMO is much higher than 0.5 in all the cases that indicates the sample is adequate for carrying out factor analysis. On the other hand, the control of Sphericity (Barlett's sig < 0.001) proves that EFA can be carried out.

Interpretations of Principal Component Analysis

In order to carry out Principal component analysis, and to identify the factors which have socio-economic impact on the respondents, there are **twenty-one** variables which are extracted into two factors which explains **60.210% of the total variance** in case of Howrah Bridge. In case of Vivekananda Setu, the variables are extracted into five exploratory factors which explains **65.316% of the total variance**. In case of Vidyasagar Setu, the variables are extracted into eight exploratory factors which explains **62.052% of the total variance**. Lastly, in case of Nivedita Setu also, it is extracted into eight exploratory factors which explains **68.350% of the total variance**.

Results of Exploratory Factor Analysis

(a) **The Howrah Bridge:** All the related variables were merged into two Exploratory Factors like:

(i) **Exploratory Factor-1:** From the above table, it is seen that the first Factor (Factor 1) consists of variables X7, X3, X1, X6, X2, X5, X4, X14, X13 & X11. Thus, the first exploratory factor with seven variables is named as **"Socio-Economic-Health Factors"**. The multiple regression equation for this variable **"Socio-Economic-Health Factors(B₁)"** is greater than 1 and is explained by the following formula:

$$\beta_1 = 0.822x_7 + 0.795x_3 + 0.790x_1 + 0.810x_6 + 0.754x_2 + 0.753x_5 + 0.727x_4 \dots \text{[ia]}$$

(ii) **Exploratory Factor-2:** From the above table, it is seen that the second Factor (Factor-2) consists of variables X8, X9 & X10. Thus, the second exploratory factor with three variables is named as “**Security Threat & Complexity**”. The multiple regression equation for this variable is shown below:

$$\text{(iii)} \quad B_2 = 0.747x_8 + 0.852x_9 + 0.751x_{10} \dots \text{[ib]}$$

Therefore, from the above equations it can be concluded that decision making in relation to the socio-economic impact of **Howrah Bridge** on the respondents (D_{SEIH}) depends on **two exploratory** factors namely, “**Socio-Economic-Health Factors**” and “**Security Threat & Complexity**” i.e., $D_{SEIH} = \beta_1 + \beta_2$

(b) **Vivekananda Setu:** All the related variables were merged into five Exploratory Factors like:

(i) **Exploratory Factor-1:** From the above table, it is seen that the first Factor (Factor 1) consists of variables X1, X2 and X3. Thus, the first exploratory factor with three variables is named as “**Positive and Negative Influence**”. The multiple regression equation for this variable is shown below:

$$B_3 = 0.784x_1 + 0.757x_2 + 0.707x_3 \dots \text{[iia]}$$

(ii) **Exploratory Factor-2:** From the above table, it is seen that the second Factor (Factor-2) consists of variables X6, x7 & X8. Thus, the second exploratory factor with three variables is named as “**Effect on Climate and Environment**”. The regression equation for this variable is shown below:

$$B_4 = 0.869x_6 + 0.850x_7 + 0.744x_8 \dots \text{[iib]}$$

(iii) **Exploratory Factor-3:** From the above table, it is seen that the third Factor (Factor-3) consists of variables X9 & X10. Thus, the third exploratory factor with two variables is named as “**Ease of Consumables and Occupation**”. The multiple regression equation for this variable is given below:

$$B_5 = 0.776x_9 + 0.718x_{10} \dots \text{[iic]}$$

(iv) **Exploratory Factor-4:** From the above table, it is seen that the fourth Factor (Factor-4) consists of variables X17 & X18. Thus, the fourth exploratory factor with two variables is named as “**Health & Medical Facilities**”. The multiple regression equation for this variable is given below:

$$B_6 = 0.903x_{17} + 0.869x_{18} \dots \text{[iic]}$$

(v) **Exploratory Factor-5:** From the above table, it is seen that the fifth Factor (Factor-5) consists of variable X19 only. Thus, the fifth exploratory factor with one variable is named as “**Changes in Livelihood Patten**”. The regression equation for this variable is given below:

$$B_7 = 0.707x_{19} \dots \text{[iie]}$$

Again, from the above equations it can concluded that decision making in relation to the socio-economic impact of the **Vivekananda Setu** on the respondents (D_{SEIV}) depends on **seven** factors namely, “**Positive and Negative Influence**”, “**Effect on Climate and Environment**”, “**Ease of Consumables and Occupation**”, “**Health & Medical Facilities**” and “**Changes in Livelihood Patten**” i.e., $D_{SEIV} = \beta_3 + \beta_4 + \beta_5 + \beta_6 + \beta_7$

(c) **Vidyasagar Setu:** All the related variables were merged into eight Exploratory Factors like:

- (i) **Exploratory Factor-1:** From the above table, it is seen that the first Factor (Factor 1) consists of variable X1. Thus, the first exploratory factor with one variable is named as “**Higher Education Facilities**”. The multiple regression equation for this variable is shown below:
 $B_8 = 0.710x_1$ [iiia]
- (ii) **Exploratory Factor-2:** From the above table, it is seen that the second Factor (Factor-2) consists of variables X6 & X7. Thus, the second exploratory factor with two variables is named as “**Danger & Disaster**”. The regression equation for this variable is shown below:
 $B_9 = 0.973x_6 + 0.962x_7$ [iiib]
- (iii) **Exploratory Factor-3:** From the above table, it is seen that the third Factor (Factor-3) consists of variables X8 & X9. Thus, the third exploratory factor with two variables is named as “**Differences in Livelihood**”. The multiple regression equation for this variable is shown below:
 $B_{10} = 0.794x_8 + 0.721x_9$ [iiic]
- (iv) **Exploratory Factor-4:** From the above table, it is seen that the fourth Factor (Factor-4) consists of variables X10 & X11. Thus, the fourth exploratory factor with two variables is named as “**Ease of Life**”. The multiple regression equation for this variable is shown below:
 $B_{11} = 0.804x_{10} + 0.755x_{11}$ [iiid]
- (v) **Exploratory Factor-5:** From the above table, it is seen that the fifth Factor (Factor-5) consists of variable X12 and x13. Thus, the fifth exploratory factor with two variables is named as “**Effect on Climate and Environment**”. The regression equation for this variable is shown below:
 $B_{12} = 0.777x_{12} + 0.728x_{13}$ [iiie]
- (vi) **Exploratory Factor-6:** From the above table, it is seen that the sixth Factor (Factor-6) consists of variable X15. Thus, the sixth exploratory factor with one variable is named as “**Illegal Activities**”. The regression equation for this variable is shown below:
 $B_{13} = 0.706x_{15}$ [iiif]
- (vii) **Exploratory Factor-7:** From the above table, it is seen that the seventh Factor (Factor-7) consists of variable X17. Thus, the seventh exploratory factor with one variable is named as “**Increased Cost of Living**”. The regression equation for this variable is shown below:
 $B_{14} = 0.733x_{17}$ [iiig]
- (viii) **Exploratory Factor-8:** From the above table, it is seen that the eighth Factor (Factor-8) consists of variable X20. Thus, the eighth exploratory factor with one variable is named as “**Increased Medical Facilities**”. The regression equation for this variable is given below:
 $B_{15} = 0.764x_{20}$ [iiih]

Again, from the above equations it can concluded that decision making in relation to the socio-economic impact of the **Vidyasagar Setu** on the respondents (**D_{SEIVK}**) depends on **eight** factors namely, “**Higher Education Facilities**”, “**Danger & Disasters**”, “**Differences in Livelihood**”, “**Ease of Life**”, “**Effect on Climate and Environment**”, “**Illegal Activities**”, “**Increased Cost of Living**” and “**Increased Medical Facilities**” i.e., $D_{SEIVK} = \beta_8 + \beta_9 + \beta_{10} + \beta_{11} + \beta_{12} + \beta_{13} + \beta_{14} + \beta_{15}$

- (d) **Nivedita Setu:** All the related variables were merged into eight Exploratory Factors like:

(i) Exploratory Factor-1: From the above table, it is seen that the first Factor (Factor 1) consists of variables X1, X2, X3, X4, X5 and X6. Thus, the first exploratory factor with six variables is named as **“Facilities and Increased Standard of Living”**. The multiple regression equation for this variable **“Facilities and Increased Standard of Living(B₁₆)”** is greater than 1 and is explained by the following formula:

$$B_{16} = 0.825x_1 + 0.800x_2 + 0.798x_3 + 0.793x_4 + 0.763x_5 + 0.727x_6 \dots\dots\dots [iva]$$

(ii) Exploratory Factor-2: From the above table, it is seen that the second Factor (Factor-2) consists of variables X7, X8 and X9. Thus, the second exploratory factor with three variables is named as **“Adverse Effect on Climate and Illegal Logging”**. The multiple regression equation for this variable is shown below:

$$B_{17} = 0.844x_8 + 0.866x_7 + 0.772x_9 \dots\dots\dots [ivb]$$

(iii) Exploratory Factor-3: From the above table, it is seen that the third Factor (Factor-3) consists of variables X10 & X11. Thus, the third exploratory factor with two variables is named as **“Life Danger and Social Variations”**. The multiple regression equation for this variable is shown below:

$$B_{18} = 0.883x_{10} + 0.862x_{11} \dots\dots\dots [ivc]$$

(iv) Exploratory Factor-4: From the above table, it is seen that the fourth Factor (Factor-4) consists of variables X13 & X14. Thus, the fourth exploratory factor with two variables is named as **“Urban Movement and Higher Education”**. The regression equation for this variable is given below:

$$B_{19} = 0.824x_{13} + 0.725x_{14} \dots\dots\dots [ivd]$$

(v) Exploratory Factor-5: From the above table, it is seen that the fifth Factor (Factor-5) consists of variable X15. Thus, the fifth exploratory factor with two variables is named as **“Change in Livelihood Pattern”**. The regression equation for this variable is shown below:

$$B_{20} = 0.805x_{15} + 0.728x_{13} \dots\dots\dots [ive]$$

(vi) Exploratory Factor-6: From the above table, it is seen that the Sixth Factor (Factor-6) consists of variable X17. Thus, the sixth exploratory factor with one variable is named as **“Time and Cost-Effective Occupation”**. The regression equation for this variable is shown below:

$$B_{21} = 0.847x_{17} \dots\dots\dots [ivf]$$

(vii) Exploratory Factor-7: From the above table, it is seen that the seventh Factor (Factor-7) consists of variable X19. Thus, the seventh exploratory factor with one variable is named as **“Increased Cost of Living”**. The regression equation for this variable **“Increased Cost of Living(B₂₂)”** is greater than 1 and is explained by the following formula:

$$B_{22} = 0.822x_{19} \dots\dots\dots [ivg]$$

(viii) Exploratory Factor-8: From the above table, it is seen that the eighth Factor (Factor-8) consists of variable X20. Thus, the eighth exploratory factor with one variable is named as **“Cultural Exchange”**. The regression equation for this variable is shown below:

$$B_{23} = 0.774x_{20} \dots\dots\dots [ivh]$$

Again, from the above equations it can be concluded that decision making in relation to the socio-economic impact of the **Nivedita Setu** on the respondents (**D_{SEIN}**) depends on **eight** factors namely, **“Facilities and Increased Standard of Living”**, **“Adverse Effect on Climate and Illegal Logging”**,

“Life Danger and Social Variations”, “Urban Movement and Higher Education”, “Change in Livelihood Pattern”, “Time and Cost-Effective Occupation”, “Increased Cost of Living” and “Cultural Exchange” i.e., $D_{SEIN} = \beta_{16} + \beta_{17} + \beta_{18} + \beta_{19} + \beta_{20} + \beta_{21} + \beta_{22} + \beta_{23}$

Interpretations of Garrett Ranking

After completing the Exploratory Factor Analysis of four bridges with primary data collected from 130 respondents each, we found the total of 23 exploratory factors, comprising of 2 factors from the Howrah Bridge, 5 factors from the Vivekananda Setu, and 8 factors from the Vidyasagar Setu and Nivedita Setu each. But some of them were common factors as identified by the respondents. So, the final factors coming out in common are: -

- 1) Socio-economic health factors (f1)
- 2) Security threats and complexity (f2)
- 3) Positive & Negative influence (f3)
- 4) Effect on climate and environment (f4)
- 5) Ease of consumables and occupation (f5)
- 6) Changes in livelihood pattern (f6)
- 7) Higher education facilities (f7)
- 8) Danger and disaster (f8)
- 9) Ease of life (f9)
- 10) Illegal Activities (f10)
- 11) Increased cost of living (f11)
- 12) Health and medical facilities (f12)
- 13) Increased standard of living (f13)
- 14) Urban movement and higher education (f14)
- 15) Cultural exchange (f15)

Here, we found the limitations of quantitative research because the exploratory factors were named only, but how much they impacted the socio-economic activities of the respondents could not be found out properly. For that purpose, we switched over to qualitative research involving some common factors & common respondents. We used focus group discussion with time scale modified approach, where we asked the respondents to rank the factors in an unbiased manner. Finally, we identified 40 common respondents and asked them to rank these factors. After that we used Garrett Ranking Method

The related analysis is presented below:

Step - 1: At first, we put all the ranks separately given by 40 respondents for 15 factors.

Step-2: With the help of frequency distribution table the overall rank given by the 40 respondents were established.

Step-3: After that we evaluated the percentage positional value with the help of $100(R_{ij}-0.5)/N_j$ formula whereas, R_{ij} =Rank given by the variable by j^{th} respondent. [N_j = Number of variables].

Step- 4: Then we evaluated the Percentage position with the corresponding Henry Garrett Score or value (with the help of Garrett Table).

Table 2.: Calculation of Garrett Score for Each Percentage Value

RANK	Percent Position Value	Garrett Value
1	3.333	85
2	10.000	75
3	16.667	69
4	23.333	64
5	30.000	60
6	36.667	57
7	43.333	53
8	50.000	50
9	56.667	47
10	63.333	43
11	70.000	39
12	76.667	36
13	83.333	31
14	90.000	24
15	96.337	15

(Source: Author's own Tabulation)

Step-5: After that, we multiplied the overall ranking (table 2) with Garrett value for 15 factors and formulated the total value of each factor as well.

Step-6: Finally, we divided the total value of each factor with the number of respondents to make average score & most importantly we evaluated the ultimate rank given by the 40 respondents for each factor.

Table 3.: Calculation of Average Score with Final Garrett Rank

Average Score			
Factor	Total	Average Score	Rank
F1	2899	72.475	15
F2	2900	72.500	14
F3	2901	72.525	13
F4	2902	72.550	12
F5	2903	72.575	11
F6	2904	72.600	10
F7	2905	72.625	9
F8	2906	72.650	8
F9	2907	72.675	7
F10	2908	72.700	6
F11	2909	72.725	5
F12	2910	72.750	4

F13	2911	72.775	3
F14	2912	72.800	2
F15	2913	72.825	1

(Source: Author's own Tabulation)

From the above table we can easily see that 40 respondents gave

1. 'Cultural exchange' as the highest rank 1 (i.e., 72.825%),
2. 'Urban movement and higher education' as the 2nd highest rank (72.800%),
3. 'Increased standard of living' as 3rd rank (72.775%),
4. 'Health and medical facilities' as 4th rank (72.750%),
5. 'Increased cost of living' as 5th rank (72.725%),
6. 'Illegal Activities' as the 6th rank (72.700%)
7. 'Ease of life' for the 7th rank (72.675%)
8. 'Danger and disaster' for the 8th rank (72.650%)
9. 'Higher education facilities' for the 9th rank (72.625%)
10. 'Changes in livelihood pattern' for the 10th rank (72.600%)
11. 'Ease of consumables and occupation' for the 11th rank (72.575%)
12. 'Effect on climate and environment' for the 12th rank (72.550%)
13. 'Positive & Negative influence' for the 13th rank (72.525%)
14. 'Security threats and complexity' for the 14th rank (72.500%)
15. 'Socio-economic health factors' for the 15th i.e., lowest rank (72.475%)

VII. Conclusion

The present research work, while applying social costs-benefits analysis to the explanation of stakeholder behaviour, has incorporated the social impact of the infrastructure project into the analysis and conceived of stakeholder relationship as inherently nested. Social impact is considered as a consequence or effect of decisions or interventions undertaken which led to development. It can also be considered as a social consequence of development or the issues that directly or indirectly affect people. The main purpose of this study was to identify and demonstrate a concept of the social impacts of infrastructure projects and as a result we obtained a set of outputs and outcomes which demonstrates different social impacts (costs and benefits) for the project. It allows us to formulate the hypothesis that the higher the level of outputs (and outcomes) perception by the stakeholders group, the better the perception of positive impact – benefits. So Social Relation Management should consider stronger interests in reference to those stakeholders who notice outputs of the project to a greater extent. This conclusion is consistent with the theory, which states that positive outcomes should maximize rather than minimize negative effects.

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Impact of Dividend Payout on Firm's Performance: Study on a Pharmaceutical Company in India in 2004 to 2020

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Abstract

The basic purpose of the study is to investigate the relationship between dividend payout and determinants of dividend. Research design/methodology-the sample contains a listed pharmaceutical company in the year 2004 to 2020, time-series data were calculated from the financial statement of the selected firms. Return on asset (ROA) and return on equity (ROE) and earnings per share (EPS) were used as independent variables while dividend payout (DPO) as dependent variables. Descriptive statistic, correlation, and multiple regressions were used as data analysis techniques. The period of the study is an important considering factor. In account, calculated P's value of all variables indicated the significant level of the variable is considered model. Based on the objective of the study concluded that's **first**, each determinant of the dividend payout may not equally significant like EPS. **Secondly**, the association between the independent variable and dependent variable not is the same. And **thirdly**, the degree of association between the dependent variable and the independent variable's value was not equal.

Keywords: *Trend analysis, Pool regression, EPS, ROE, Dividend payout, and ROA.*

Introduction

Every company pays the dividend after a certain period. Initially, the company board meeting decided that how much profit distribute and retain for the company's further investment or development purpose for the future. The study gives us a clear picture of the different determinants of dividend payout and which kind of associations are there for the selection of dividends that are affected by the determinants of financial components of a company. On the other hand, the historical reports of the company said the next investment opportunity for the outsider or stockholder. When any investors invested capital in a particular company they followed and looked up the different financial parameters of the company, dividend payout is one of them. In our study consider the three tools of financial statement of the company such as 1. Earnings per share, 2. Return on equity and 3. Return on assets. Jensen (1986) and Roseff (1982) concluded that companies can use dividend payments to reduce agency problems. When shareholders do not receive dividends, managers begin to use these resources for their benefit. Help companies understand how to control agency fees by managing dividend

policies.ⁱ Dividend payout is, therefore, taken into consideration to be one of the vital monetary choices that company managers encounter (Baker and Powell, 1999).ⁱⁱ Straitis and Wu (2004) suggested reducing dividend payments to shareholders. Dividends can be used to reduce the company's over-investment problems.ⁱⁱⁱ

Jensen (1986) believes that paying dividends to shareholders will reduce management's control of resources. Dhanani (2005) uses survey methods to capture the opinions and attitudes of company managers on dividend policy and finds that dividend policy helps to add value to the company's market.^{iv} Frankfurt and McGoon (2000) concluded that the dividend problem, whether in terms of appreciation or politics, is one of the most difficult problems in modern finance. Mizuno (2007) agrees with the fact that if a company cannot determine a suitable investment that can generate higher returns than shareholders expect, it must pay dividends to shareholders.^v

Researchers have different opinions on whether dividend payments have a significant long-term impact on stock prices.^{vi} This has potential effects on stock prices, investor returns, domestic growth funds, and capital bases through equity holdings and leverage and leverage (Omran and Pointon, 2004).^{vii} Facio et al. (2004) believe that the empirical research to infer the causal relationship between returns and dividends is based on short-term and therefore misleads potential investors. Therefore, dividends have no explanatory power for predicting future returns.^{viii} Therefore, this study attempts to find out whether there is a connection between dividend payments and company performance.

Relevance of the study

Generally, the study depends on determinants of dividend payout and its association of the relationship in the practical life for analysis. There were many tools are there for analyzing the company's overall performance such as EPS, PBIT, PE, etc. and dividend payout is one of them. This study attempts to examine some of the features that determine the behavior of firms' dividend payouts ratio in the Indian company. The contradictory and conflicting response to the question on the relevance of dividend payout on its determinants of firms' performance informed the need for this study. This study aims to examine the possible effect that a firm's dividend payout might have on the investor's interest and the resulting impact it could have on the financial performance of a company.

Company's profile

Dr. Reddy's Laboratories is an Indian multinational pharmaceutical company placed in Hyderabad, Telangana, India. The employer changed into founded by way of Anji Reddy, who previously labored inside the mentor institute Indian tablets and prescribed drugs restrained.^{ix} Dr. Reddy manufactures and markets a wide variety of prescription drugs in India and foreign places. The agency has over one hundred ninety medications, 60 energetic pharmaceutical elements (APIs) for drug manufacture, diagnostic kits, crucial care, and biotechnology merchandise.

Dr. Reddy's commenced as a provider to Indian drug producers, but it quickly commenced exporting to different much less-regulated markets that had the gain of not having to spend time and money on a production plant that might gain approval from a drug licensing frame inclusive of the U.S. meals and Drug Administration (FDA). by using the early 1990s, the multiplied scale and profitability from those unregulated markets enabled the company to begin focusing on getting approval from drug regulators for their formulations and bulk drug manufacturing vegetation - in more advanced economies. This allowed their motion into regulated markets together with The USA and Europe. In 2014, Dr. Reddy Laboratories become indexed among 1200 of India's maximum depended on brands in keeping with the brand consider record 2014, a take a look at performed using accept as true with research Advisory, an emblem analytics business enterprise.^x

by way of 2007, Dr. Reddy's had seven FDA plant life producing lively pharmaceutical substances in India and seven FDA-inspected and ISO 9001 (nice) and ISO 14001 (environmental management) certified plants making affected person-ready medications – five of them in India and within the United Kingdom^{xi}

In 2010, the family-managed Dr Reddy's denied^{xii} that it became in talks to sell its generics business in India to US pharmaceutical large Pfizer,^{xiii} which were suing the business enterprise for alleged patent infringement after Dr Reddy's introduced that is supposed to provide a customary version of atorvastatin, advertised by way of Pfizer as Lipitor, an anti-ldl cholesterol remedy. ^{xivxv}Reddy's changed into already linked to UK prescription drugs multinational Glaxo Smithkline.^{xvi}

Conceptual framework of the study

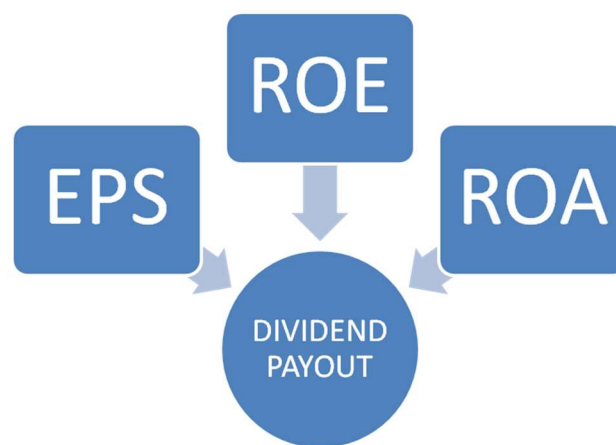
The conceptual model given here was formulated through extensive study.

The model suggests the relationship between the determinants of the dividend payout of the company. Dividend payout, the dividend payout ratio is the amount of dividends paid to stockholders relative to the quantity of overall internet profits of a corporation. The quantity that isn't always paid out in dividends to stockholders is held by way of

the business enterprise for growth. The amount this is stored via the organization is called retained income.

Dividend payout ratio= dividend /internet income

The dividend payout ratio is the quantity of dividends paid to stockholders relative to the amount of total internet earnings of an organization. The amount that is not paid out in dividends to stockholders is held by means of the business enterprise for boom. The amount this is saved by using the company is referred to as retained income.



Net earnings proven inside the formula may be observed on the organization's income statement. This formula is used by some while considering whether or not to invest in a profitable organization that can pay out dividends versus a profitable company that has excessive increase potential. In different words, this method takes into attention consistent profits versus reinvestment for viable future income, assuming the company has net profits.

Alternative Formula

I. 1-retention ratio

The retention ratio and the dividend payout ratio collectively identical 1 or 100% of net profits. the idea is that something amount now not paid in dividends is saved by way of the employer to reinvest for expansion.

Alternatively, an organization that can pay no dividends could have a 0 dividend payout ratio and a 1 retention ratio, which means that that the employer reinvests all of their internet income for growth.

II. Dividend consistent with proportion (DPS)/income consistent with percentage(EPS)

The dividend payout ratio method can also be restated on an "according to percentage" foundation. If the dividend consistent with proportion and earnings in keeping with proportion is known, the dividend payout ratio may be calculated using the identical concept of dividends paid divided through income, or internet profits.

Income in line with share (EPS) is the part of a corporation's profit allocated to each first-rate share of common stock. Profits per percentage function as a hallmark of an employer's profitability.

EPS=(internet income – favored dividend)/weighted common proportion exquisite.

Return on equity (ROE) is the quantity of net profits back as a percentage of shareholders' fairness. return on fairness (additionally referred to as "return on net worth" [RONW] measures an enterprise's profitability by means of revealing how a good deal profit an agency generates with the cash shareholders have invested.

ROE is expressed as a percentage and calculated as:

ROE= net earnings/Shareholder's equity

Return on assets (ROA) is an indicator of how profitable a company is relative to its total assets. ROA gives a manager, investor, or analyst an idea as to how efficient a company's management is at using its assets to generate earnings. Return on assets is displayed as a percentage and it's calculated as:

ROA = Net Income / Total Assets

Literature of the study

Modigliani and Miller (1961) pointed out that "the theoretical principles behind the dividend policy and its business impact can be described as dividend-independent or dividend-related theories". Therefore, the dividend policy has nothing to do with the cost of capital and value. There are no companies in the world with taxes and transaction costs. This shows that if investors can create any

income model by buying and selling stocks, it depends on how the company distributes dividends so that the expected return required for them to own the company's stock will not change and the issuance of new shares. It should be noted that company assets, investment opportunities, expected future net cash flows, and cost of capital are not affected by dividend policy options.

Pruitt and Gitman (1991) studied and found that risk is also an important determinant of a company's dividend policy, and concluded that companies with relatively stable earnings can often roughly predict their future earnings. Compared with companies with fluctuating profits, such companies are more likely to pay a higher percentage of profits.

Amidou and Abor (2006) studied the determinants of the dividend rate of companies listed on the African Stock Exchange for 6 years on a financial reporting platform. The results of this study show that there is a significant positive correlation between the dividend payment rate and cash income. There is a significant negative correlation between cash flow and taxation, dividend payment rate and risk, institutional ownership, development, and market value and book value. Fario et al. (2004) believe that there is no significant link between dividends and long-term returns, and studies showing this link are based on short-term, thus misleading investors. They proposed three scenarios that ignore the ratio of long-term dividends to future earnings.

Lee (2005) believes that companies that increase distribution have excessive financial flexibility, and at the same time exhibit positive earnings shocks and lower earnings volatility, but there is limited evidence of subsequent performance improvement. The volatility continues to decline, which can be explained by the fact that managers will increase the company's salary if they believe that the probability of maintaining the current income level is high. Volatility is higher than other companies, and this volatility is increasing. Tahir and Raja (2014) used regression and correlation in their study titled "The Impact of Dividend Policy on Shareholder Welfare" to determine the most appropriate model for Pakistan Oil and Gas Company's PD and its impact study from 1999 to 2006. Dividend payout ratio (DPR), price-to-earnings ratio (PER), book value and equity market value (BV / MV), and return on holding ratio are treated as response variables as predictors. The results show that there is a correlation between the predictor variable and the response variable. Pakistan's oil and gas industry pays dividends regularly, but due to company stock price fluctuations and company fluctuations, due to ineffective returns, there is uncertainty in the stock market. Research has found that the dividend payment rate has almost no relationship with withholding time.

Kumaresan (2014) focused on the top ten companies in Sri Lanka in a study titled "The Impact of Dividend Policies on Shareholder Wealth: A Study of Listed Companies in the Hotel and Tourism Industry in Sri Lanka". In the hotel and tourism industry in Sri Lanka, from 2008 to 2012, the response variable is EPS, and the predictive variables are: return on equity (ROE), DPR, and dividend per share (DPS.), And retention rate (RR). Correlation and regression analysis of data collected from the top ten

listed companies in the hotel and tourism industry. The study found that the return on equity (ROE), dividends per share (DPS), and dividend payment (DPO) of selected companies in the hotel and tourism industry in Sri Lanka is positively correlated with SW, and the study also found that retention rates and There is a negative correlation between shareholder wealth.

The objective of the study

The following objectives are taken for the study:

1. To find out the relationship between determinants of dividend payout for pharmaceutical Company's in India.
2. To find out the impact of dividend payout's determinants on dividend payout of pharmaceutical companies in India.

Method of the study

The methodology section consists of the sample size and data collection sources, the different models used, and the definition of the different variables used in the study.

Data Collection Sources and Sample Size and period of the study:

Data for the study has been collected from the Bombay Stock Exchange (BSE) of the selected company's annual reports, balance sheet, and financial statement. With the help of the purposive sampling system selected (dr. Raddis lab Ltd). The period of the study is to be considered from 2004 to 2020(eighteen years).

	Mar-20	Mar-19	Mar-18	Mar-17	Mar-16	Mar-15	Mar-14	Mar-13	Mar-12	Mar-11	Mar-10	Mar-09	Mar-08	Mar-07	Mar-06	Mar-05	Mar-04
Dividend Payout Ratio (NP) (%)	13.32	25.99	70.41	24.22	25.13	20.29	15.84	20.13	25.54	21.31	22.45	18.77	13.31	5.38	18.16	58.44	13.5
Return on Assets (%)	15.08	7.86	3.31	8.41	7.71	10.2	13.32	10.55	8.82	9.64	10.11	7.62	7.11	19.61	5.29	2.19	11.24
Return on Networth / Equity (%)	19.33	10.07	4.8	11.93	11.67	15.79	20.71	16.25	13.58	14.84	14.3	10.66	9.84	26.72	9.33	3.15	13.83
Basic EPS (Rs.)	177.23	76.98	34.19	83.05	79.42	98.6	113.67	74.54	53.83	52.82	50.12	33.3	28.17	69.6	27.53	8.55	37.01

Earnings Yield	Price/Net Operating Revenue	Price/BV (X)	Retention Ratios (%)	MarketCap/Net Operating Revenue	EV/EBIT DA (X)	EV/Net Operating Revenue (X)	Enterprise Value (Cr.)	Cash Earnings Retention Ratio (%)	Earnings Retention Ratio (%)	Dividend Payout Ratio (CP) (%)	
0.06	4.37	3.41	86.67	4.37	14.62	4.46	52,829.90	89.5	86.68	10.5	Mar-20
0.03	4.33	3.63	74	4.33	18.45	4.41	46,829.39	83.87	74.01	16.13	Mar-19
0.02	3.69	2.93	29.58	3.69	24.15	3.96	37,036.77	70.24	29.59	29.76	Mar-18
0.03	4.49	3.76	75.77	4.49	19.66	4.73	45,935.25	84.18	75.78	15.82	Mar-17
0.03	5.07	4.46	74.86	5.07	20.23	5.25	53,591.39	83.01	74.87	16.99	Mar-16
0.03	5.94	5.59	79.7	5.94	23.59	6.16	61,649.55	84.3	79.71	15.7	Mar-15
0.04	4.48	4.67	84.15	4.48	15.65	4.69	45,584.22	86.77	84.16	13.23	Mar-14
0.04	3.56	3.85	79.86	3.56	14.41	3.64	30,661.77	83.86	79.87	16.14	Mar-13
0.03	4.43	4.44	74.45	4.43	18.79	4.53	30,511.10	80.8	74.46	19.2	Mar-12
0.03	5.23	4.61	78.68	5.23	22.3	5.49	29,102.17	83.32	78.69	16.68	Mar-11
0.04	4.9	3.64	77.54	4.9	16.58	4.95	21,747.58	82.54	77.55	17.46	Mar-10
0.07	2.06	1.56	81.22	2.06	9.05	2.12	8,484.77	86.4	81.23	13.6	Mar-09
0.05	2.97	2.07	86.68	2.97	13.11	2.95	9,863.15	90.4	86.69	9.6	Mar-08
0.1	3.23	2.79	94.61	3.23	7.24	2.93	11,088.80	95.24	94.62	4.76	Mar-07
0.02	5.44	4.82	81.83	5.44	28.44	5.57	11,165.86	88.58	81.84	11.42	Mar-06
0.01	3.65	2.73	41.55	3.65	35.83	3.25	5,037.03	76.55	41.56	23.45	Mar-05
0.04	4.49	3.64	86.49	4.49	18.91	4.28	7,102.71	89.23	86.5	10.77	Mar-04

<https://www.moneycontrol.com/india/stockpricequata/pharmaceutical/dr.raddieslab>

The model to be used:

The study used fifteen years of financial data on the variables of earning per share, return on assets and return on equity of Sun Pharma Company. On the basis of the objective of the study used AR regression model.

$$y_t = b_1x_1 + b_2x_2 + b_3x_3 + E_{it}$$

y = dividend payout

X_1 = earnings per share (EPS)

X_2 = return on equity (ROE)

X_3 = return on assets (ROA)

E_i = error portion of the model.

t = time period of the model (17 years)

Analyze and finding**Descriptive statistic****Table 1**

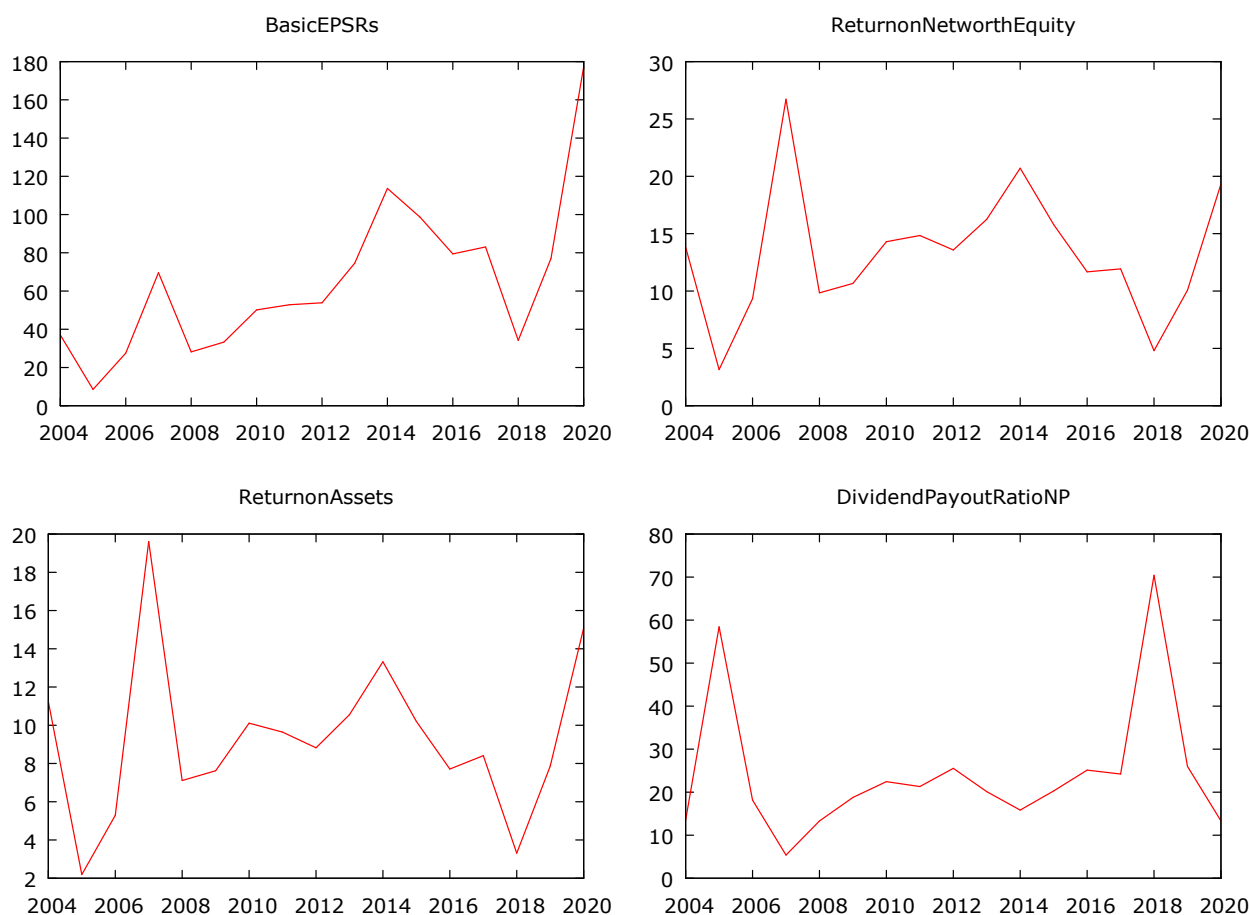
	Mean	Median	Minimum	Maximum	Std. Dev.	C.V.	Skewness	Ex. kurtosis
Basic EPS	64.624	53.830	8.55	177.23	40.357	0.625	1.2112	1.6093
Return on Networth	13.341	13.580	3.15	26.72	5.6729	0.425	0.42435	0.40359
Return on Assets	9.2982	8.820	2.19	19.61	4.1723	0.449	0.62455	0.69081
Dividend Payout	24.246	20.290	5.38	70.41	16.199	0.668	1.9196	2.8688

Table -1 shows the descriptive statistic of the studies, considered four variables that were related to the company's performance. In descriptive statistics calculated mean, median, stander deviation, covariance and skewness, and kurtosis. In the case of basic earnings per share mean and median values are 64.62 and 53.38, and the stander deviation value is 40.35 with consideration to the mean value. Also considered are the covariance, skewness, and kurtosis measured for the magnitude of how far from a normal distribution. On the other hand, the same interpretations are for the rest of the variables.

Trend analysis

If we considered the periodical trend of variables, some critical questions may arise for the variable of **earning per share** gradually increase from the year 2004 to 2009 then the trend line had been fall down till 2018.

And for **return on equity** had been gradually decreased from the year of 2004 to 2014 then gradually increase till 2018. And for **return on assets** also flowed the same trend like **return on equity**. But for the **dividend payout** had been flowed neutral trend from 2004 to 2016 then suddenly fall down and then recovered again got the previous position, it's a dependent variable in the study. One logical point should take into account in the year 2014 all independent variables such as EPS, ROA, and ROE respectively flowed the same trend except Dividend Payout. According to the trend of which graphically presented one cause clearly said that in the year 2014 three independent variables fall down and conclude that it's may be some relation between the variable. The studied don't search for the exact reason behind it.



Multiple regression analysis

Model : OLS, using observations 2004-2020 (T = 17)				
Dependent variable: DividendPayoutRatioNP				
	coefficient	std. error	t-ratio	p-value
Const	51.78194	7.730083	6.698756	1.47
EPS	0.047699	0.095213	0.500965	0.624771
Reurn on equity	-1.61517	2.576281	-0.62694	0.541553

ReturnonAssets	-0.97542	3.522725	-0.27689	0.786217
Mean dependent var	24.24647	S.D. dependent var	16.19865	
Sum squared resid	1868.854	S.E. of regression	11.98991	
R-squared	0.554859	Adjusted R-squared	0.452134	
F(3, 13)	5.401411	P-value(F)	0.012353	
Log-likelihood	-64.0708	Akaike criterion	136.1417	
Schwarz criterion	139.4745	Hannan-Quinn	136.4729	
Rho	-0.41076	Durbin-Watson	2.796217	

Above the table showed the fit of the model and also shows the coefficient of every variable which consider in studied and with the impact of independents variable on dividend payout. ‘rho’ indicated and measure the strength of association between the variable in hearing -0.623 means negative correlation with the considered period of the time. Above the study conducted fifteen years of periodical data which Durbin- Watson value is 2.79 which indicated that no autocorrelation is there. And the independent variables have the ability to explain the dependent variable, on the opposite site fitness of model appropriately green signal, because R’s value more than 50% and adjusted R’s square value is also logical position with compare to the R’s square value. And p’s value is less than .05 with the connection of F’s statistic. All the above values supported that the model is appropriate for explain of the association between a dependent variable and an independent variable.

The coefficient value of ROE is -1.61 if the value of dividend payout increased one percent the roe decrease -1.61and other condition remains constant. So, return on equity has a negative impact on dividend payout with considered of other assumptions of the model be constant, like the time period of the study, the sample of the study, etc. and for ROA, if the values of dividend payout increase one unit the ROA decrease -0.97 units. The period of the study is an important considering factor. In account, calculated P’s value of all variables indicated the significant level of the variable is considered model.

Conclusion

In the study, we concentrated focus on the impact of corporate performance on the dividend distribution of the firm. But in the study, we selected one company from the pharmaceutical sector. For that’s why the conclusion of the study doesn’t carry the same implication for the entire sector based on the observation of the contemplation. The thought on the particular data which collected a specific firm and some conclusions have drawn are follows:

Based on the objective of the study concluded that’s **first**, each and every determinant of the dividend payout may not equally significant like EPS. **Secondly**, the association between the independent

variable and dependent variable was not the same. And **thirdly**, the degree of association between a dependent variable and the independent variable's value was not equal.

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Vehicular pollution and the common avenue trees of the City of Calcutta - a survey on survival

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Abstract:

Air pollution is a worldwide burning problem and Kolkata is not an exception. The experiment was conducted to observe the effect of traffic derived pollutants on the road side tree lines and human health. The study is based on the analysis, traffic conditions, diversity of plants and the air pollution level of the selected study areas which are Shyambazar to Dunlop, Belgachia to Lake town, Rashbehari to Gariahat and Rabindrasadan to Park Street, some of the busiest vehicular pathway of Kolkata. The biochemical parameters like protein and chlorophyll, microbial study of the phyllosphere, and the effect of wash out of the phyllosphere of selected avenue trees on seed germination were also analysed. Experimental observations showed that the road side plants are subjected to stress due to the traffic derived pollutants and the anthropogenic pressure on the study sites.

Key Words: *Vehicular pollution, Automobiles, Microbial population, Chlorophyll, Protein.*

Introduction

The major source of air pollutants are Vehicles. Carbon dioxide (CO₂), Carbon monoxide (CO), Sulphur dioxide (SO₂), particulate matter (PM₁₀) all are emitted from automobiles and the level of pollution increases due to the increasing number of vehicles on the roads of a megacity like Kolkata. The vehicular pollution in Kolkata is attributed to a large number of automobiles running daily over only 6% available road space, causing obstruction which brings down the average vehicular speed causing heavy automobile emission (West Bengal Pollution Control Board, 2010). Kolkata with an area of 1480 square kilometre, according to an analysis of Statista Research Department, March 15, 2021 exhibits number of registered vehicles across Calcutta which are as follows.

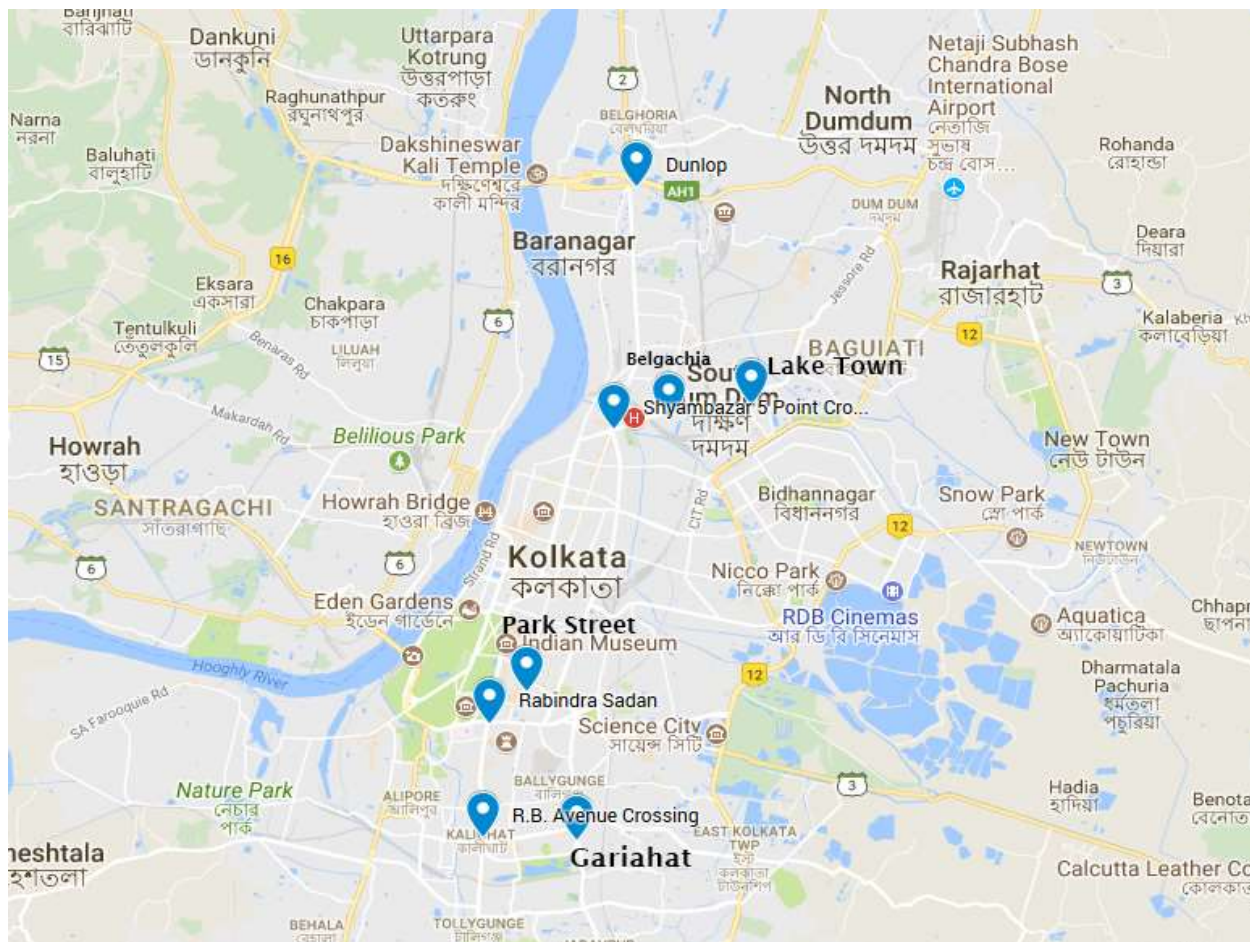
Total transport - 1823836. Two wheeler - 933326, Private cars - 631786, Light goods vehicle - 61488, Auto Rickshaw - 45415, Taxi - 34827, Heavy goods vehicle - 30830, Public bus - 16550, Total motor able road: 205 sq. km. is within Corporation Area. The number of vehicles in Kolkata has risen with an annual rate of 4%. Private cars have risen from 0.26 million in 2000 to 0.65 million in 2011, which indicates a 2.5 times increase (Bhaduri, 2013). World health organization published a report in 2002 reveals around 4.6 million people die each year due to the direct influence of air pollution (WHO,

2002). Kolkata is one of the fastest developing megacities in India but the impact of vehicular pollution in this city is highly alarming. Trees may absorb some pollutants in the natural life processes common to all plants. In realising of gases, plants take carbon dioxide to make food, and release oxygen. This gaseous exchange takes place through stomata or pores on the leaves surface. Chlorophyll is the essential components for plants and with the help of chlorophyll plants make their own food in the presence of sunlight and CO₂, water. Changes of leaf chlorophyll are relative markers of environmental pollution (Carter and Knapp, 2001). The main roads of Kolkata with heavy traffic are seen with the plantation of avenue trees with greater capacity to build canopies. These are planted to have aesthetic beauty and also in connection with the reduction of air pollution. In this study we have observed the diversity of planted plants along the roadside of four busiest area of Kolkata, which are Shyambazar to Dunlop, Belgachia to Lake town, Rashbehari to Gariahat and Rabindrasadan to Park Street. The objective of the study was to examine the effect of pollutants which are derived from the automobiles on trees and the diversity in the distribution of trees, the biochemical parameters of leaves of the selected plants due to the effect of traffic pollutants, to examine the air pollutant levels and phyllospheric microbial population study.

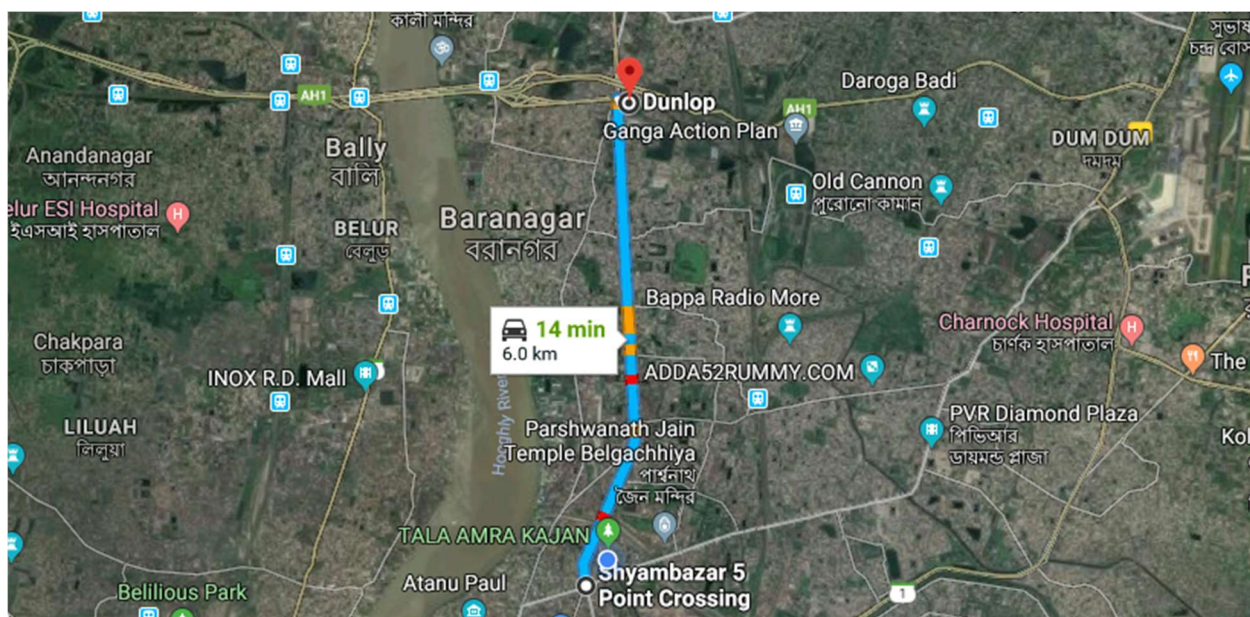
Materials and Methods:

Selection of roads and location and description

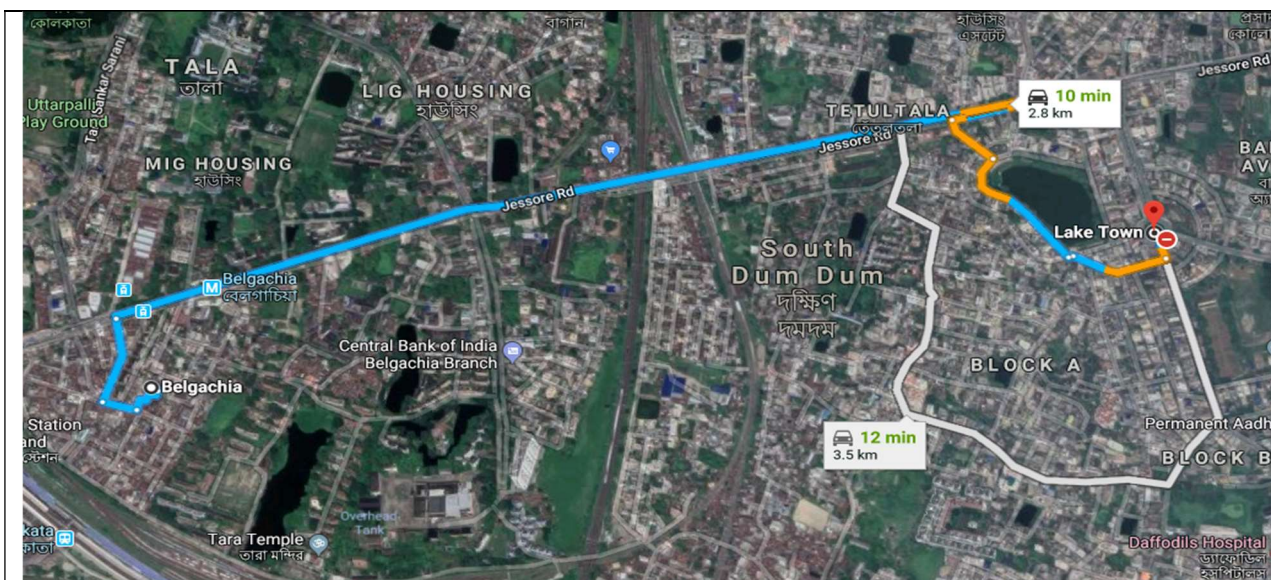
The study was conducted at four locations in Kolkata which are – (1) Shyambazar to Dunlop (2) Belgachia to Lake Town (3) Rashbehari to Gariahat (4) Rabindrasadan to Park Street. These locations were selected due to the heavy number of vehicles flowing through the study area and to examine the impact of pollutants which are derived from the automobiles on the avenue trees. Shyambazar is a neighbourhood of north Kolkata. BT road (Barrack pore Trunk Road) is a four lane road connecting Shyambazar to Barrack pore. It starts from Shyambazar five point crossing and end at Barrack pore. Dunlop crossing is one of the busiest crossing in Kolkata Belgachia and Lake Town are the neighbourhood of North Kolkata. Lake town comes under the jurisdiction of South Dum Dum Municipality in Barrack pore subdivision in North 24 Pargana district. Park street is a famous thoroughfare in the city of Kolkata and Rabindra sadan is a cultural centre in Kolkata. Rashbehari avenue is one of the most prestigious and important east west avenues of Kolkata. A major portion of this road is often commonly referred to as Gariahat, the prime shopping and aristocratic residential neighbourhood of South Kolkata. Rashbehari crossing is the busiest crossing in Kolkata. The distance between Shyambazar to Dunlop is 8 kms. Belgachia to Lake Town is 2 km. Rashbehari to Gariahat is 2 km and Rabindrasadan to Park Street is 1 km respectively that has been covered as study location.



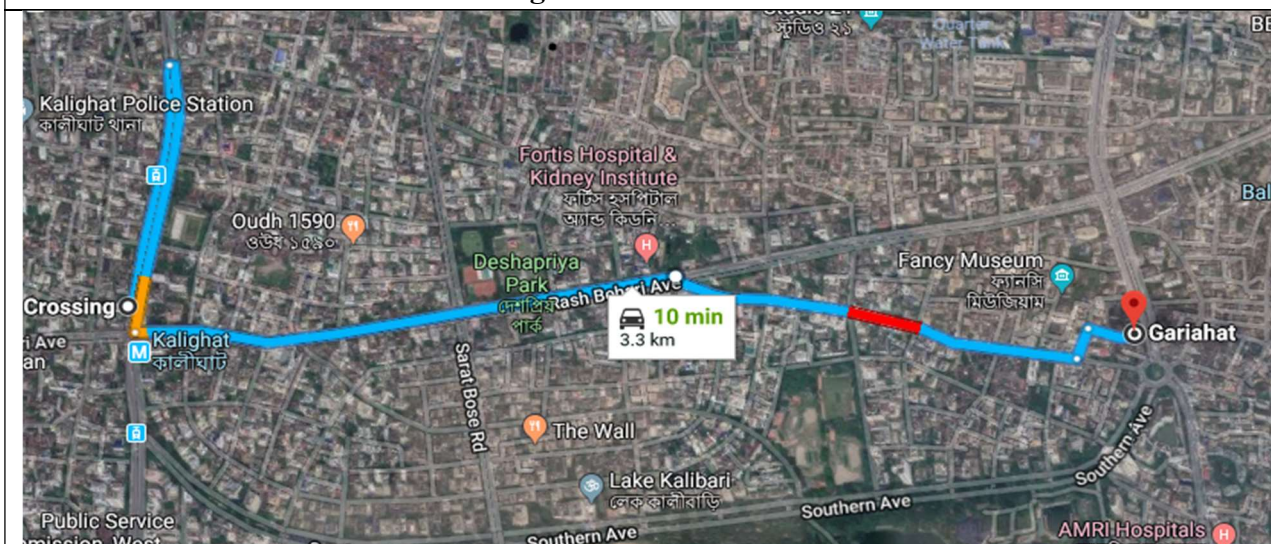
Location of the study areas in Kolkata



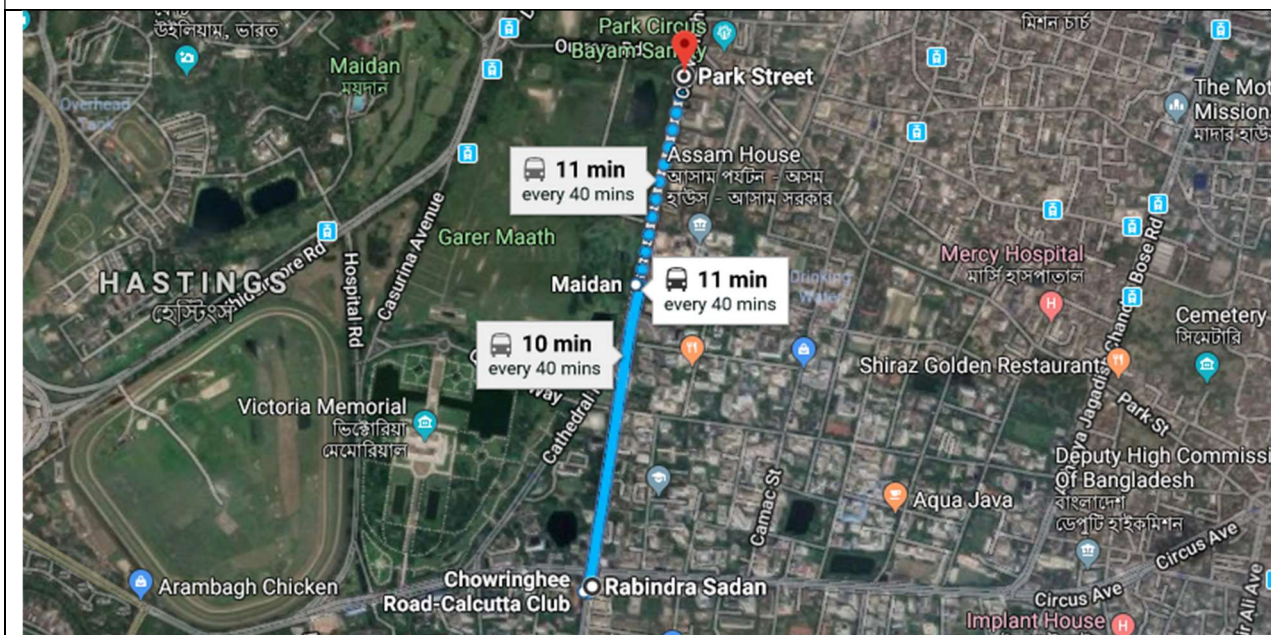
Shyambazar to Dunlop



Belgachia to Lake town



Rashbehari to Gariahat



Rabindra Sadan to Park Street

Estimation of Traffic data

Traffic data was taken from the selected study area. The number of small and large vehicles was measured for the 3 consecutive hours with an interval of 2 hour. Based on this data the number of small and large vehicles flowing per day per week and per month through these location sites were also calculated.

Estimation of air pollution level on the study area (SO₂, NO₂, PM_{2.5}, PM₁₀)

The data was collected from the website of West Bengal Pollution control board (WBPCB, 2010) by the following way – Website of WBPCB → air quality index → automatic station → select the station name (for each study area) → input the data.

Floral study

The diversity of the trees was counted manually at the four location sites and a checklist of plant species was also prepared. The number of trees of each study area were also calculated by transect method.

Methodology for biochemical parameters

Estimation of chlorophyll

The chlorophyll a, b in the leaves of *Mangifera indica*, *Ficus religiosa*, *Polyalthia longifolia*, *Alstonia scholaris*, *Psidium guajava* were estimated. 2 gm of fresh leaves with excess of 80 % acetone in a mortar with pestle was homogenized using neutral sand. The supernatant was filtered through a Buchner funnel using What man No 42 filter paper. The extraction was repeated with sufficient quantity of 80% acetone. The content was transferred from mortar to the Buchner funnel and washed with 80% acetone until it appeared colourless. The filtrate was poured and made the volume up to 50ml with 80% acetone. The absorbance (A) of this diluted extract was measured by 645 and 663 nm for the determination of chlorophyll a and b [Lichtenthaler et al., 1983]

Chlorophyll (a) (mg gm⁻¹)

$$= \frac{12.7A_{663} - 2.69A_{645}}{100 * W} * V$$

Chlorophyll (b) (mg gm⁻¹)

$$= \frac{22.9A_{645} - 4.68A_{663}}{1000 * W} * V$$

Where V= Volume of extract in ml

W= Fresh weight of the leaf sample in grams

Estimation of protein

The leaf protein of *Mangifera indica*, *Ficus religiosa*, *Polyalthia longifolia*, *Alstonia scholaris*, *Psidium guajava* were estimated. 2ml of leaf extract was collected and 2ml of ethyl alcohol was added to it and was mixed properly. It was filtered with filter paper and from this filtrate 1 ml of sample was collected. 3ml of Lowry reagent was added. Then it was incubated for 15 minutes. 0.5 ml

of Folin phenol reagent was added and it was kept in dark for 30 minutes. The absorbance of this sample was measured by 595 nm for the estimation of the protein. (Lowry et al., 1951)

Methodology for the study of microbes

Collection of plant leaves and estimation of microbes by serial dilution

The water was collected by washing the leaflets of the selected plants from four different study areas and it was poured into four separate sterilized containers. Initial dilution was prepared by adding 0.1 ml of water sample into 9.9 ml dilution blank labelled as 10^{-1} . Thus dilution was made from the original sample for 10 times. The content was vortexed to obtain the uniform distribution of the organisms. From the 1st dilution 0.1 ml of suspension was transformed to the dilution blank of 10^{-2} with pipette, thus diluting the sample 100 times from that of the original. The vortex was repeated unless the original sample had been diluted 10,000,000 times (10^{-7}) every time using a sterile pipette (Conventional method).

Spread plate method

1 ml of sample each from 10^{-3} dilution to 10^{-7} dilution was transferred to the solidified agar plates. Plates were labelled according to the study area for each dilution. With the help of the sterile glass spreader the sample was uniformly spread all over the surface of the solidifying agar medium. After addition of water suspension the plates were kept in an inverted position at 37°C for 24- 48 hours in an incubator (Conventional method).

Gram staining method

Glass slides were washed and dried. A smear of bacterial culture was prepared. The smear was air dried and fixed carefully. The slide was kept on flat surface and it was covered with crystal violet for 2 minutes. The excess stain was decanted off and washed with distilled water. Gram iodine was then added to the smear and allowed to stand for 2 minutes. The iodine was washed with 95% ethyl alcohol. The smear was counter stained with Safranin for 1 minute. The slide was carefully washed with distilled water and blotted. The slide was examined under the microscope and the cell morphology was observed (Aneja, 2007).

Methodology for seed germination

Five plates were labelled for each site according to the study area and for control. The water was collected by washing the surface of leaflet of the selected plant species and it was poured into 4 different containers. 10 fresh viable seeds of *Vigna radiata* and *Cicer arietinum* were taken on the labelled petriplate over blotting paper and 2ml of distilled water that was collected from the leaf surface from four selected sites was given in each plate to obtain the germination result with a control

set of seeds under plain water. The plates were incubated in 25°C for one day and the same process was repeated in the next two days to observe the result. (Bhattacharyya et. al . 2014).

Results and Discussion

The Google maps of the four study location were presented. (Location map 1-4) These helped to know the locations clearly. On the other hand the air pollution level in some of the megacities of India were presented and tallied with highest air pollution level in Kolkata. **Fig, 1.**

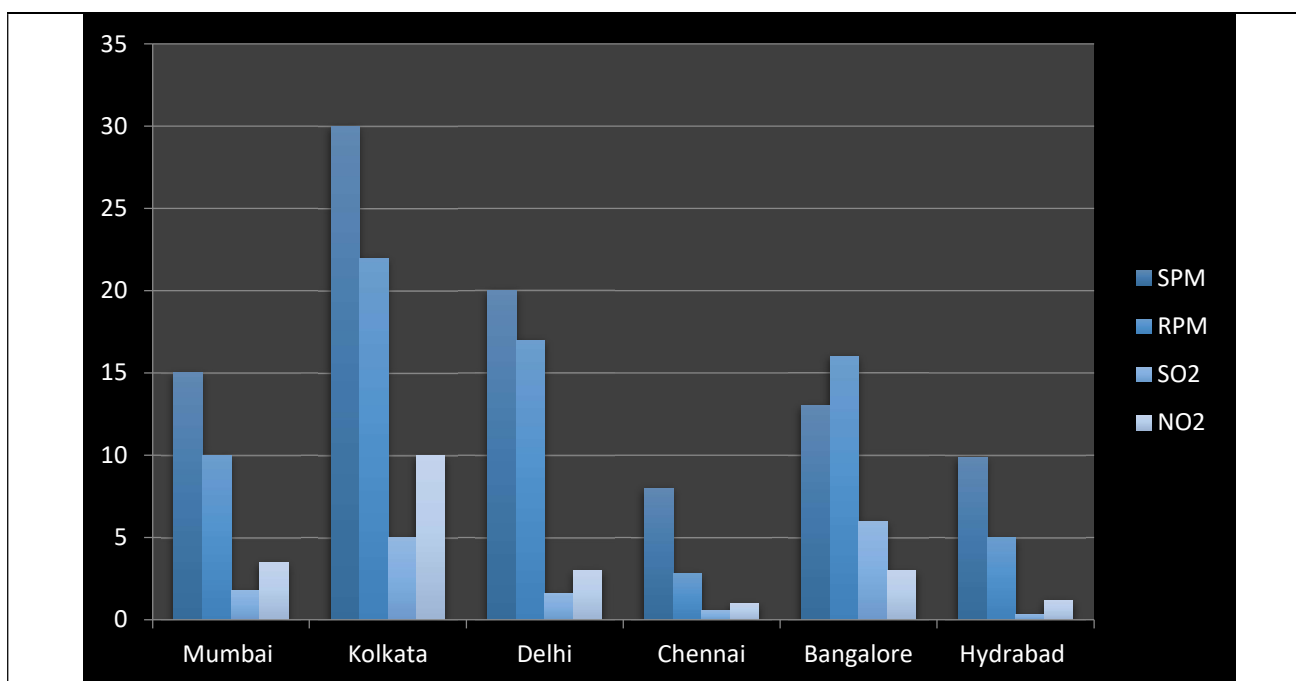


Fig. 1. Showed the air pollution level in the megacities of India. Source (Ministry of petroleum and natural gas , 2018

The air quality at Shyambazar to Dunlop, Belgachia to Lake town , Rashbehari to Gariahat showed the concentrations of the particulate matter highest in comparison to SO₂ and NO₂ concentrations and the concentrations of NO₂ remained high as compared to the SO₂ concentrations in all study areas.

Table 1 – 6.

Pollutant	Concentration ($\mu\text{g}/\text{m}^3$)	Sub Index
SO ₂	6.83	9
P.M _{2.5}	83.00	177
NO ₂	46.33	58
P.M ₁₀	160.33	140

Table 1: Air quality Index for Shyambazar (WBPCB, 10th March, 2018)

Pollutant	Concentration ($\mu\text{g}/\text{m}^3$)	Sub Index
SO ₂	9.00	11
NO ₂	47.33	60
P.M ₁₀	191.33	161

Table 2: Air Quality Index for Dunlop (WBPCB, 10th March, 2018)

Pollutant	Concentration ($\mu\text{g}/\text{m}^3$)	Sub Index
SO ₂	4.17	4.17
P.M _{2.5}	72.00	72.00
NO ₂	36.50	36.50
P.M ₁₀	141.67	141.67

Table 3: Air Quality Index for Belgachia (WBPCB, 15th March, 2018)

Pollutant	Concentration ($\mu\text{g}/\text{m}^3$)	Sub Index
SO ₂	3.33	4
NO ₂	36.17	45
P.M ₁₀	120.33	114

Table 4: Air Quality Index for Gariahat (WBPCB, 5th April, 2018)

Pollutant	Concentration ($\mu\text{g}/\text{m}^3$)	Sub index
SO ₂	4.00	5
P.M _{2.5}	50.00	83
NO ₂	31.17	39
P.M ₁₀	95.00	95

Table 5: Air Quality Index for Rabindrasadan (WBPCB, 6th April, 2018)

AQI	Remark	Air Quality Index Health Impact
0-50	Good	Minimal impact
51-100	Satisfactory	Minor Breathing Discomfort to sensitive People
101-200	Moderate	Minor Breathing Discomfort to People with Lung and Heart Disease
201-300	Poor	Breathing Discomfort to People with Lung and Heart Disease Children and Adults
301-400	Very Poor	Respiratory Illness of People on Prolonged Exposure
>400	Severe	Respiratory Effects even on Healthy People

Table 6: Air Quality Index Health Impact (WBPCB , 17th July,2018)

The data on vehicular emission clearly deals with the increasing population pressure, insufficient road space, vehicles with the age 15 years or above, congestion of slow moving vehicles in Kolkata which adds to its misery. The thick air is inhaled by the city's walker and the traffic police are the worst sufferer. The West Bengal Pollution Control Board (WBPCB) provided us detailed information regarding the air pollution level of selected sites of the city from the month of **March to April, 2018**. This data showed that there is a great intensity of air pollution at these selected sites. **Table 1 – 6.**

The number of small and large vehicles along the road of the study areas were presented in Table and in Graphical representation which showed maximum number vehicles passes through the Shyambazar to Dunlop followed by Rabindra sadan to Park street , Rashbehari to Gariahat and Belgachia to Lake Town both for small and Large vehicles. So , it can be easily estimated the level of air pollution from the vehicular emission in this area. This observation helped us to correlate the pollution strata of those areas which are faced by the avenue trees along side of these roads. **Fig. 2** showed the average density of vehicles flowing (a) per hour (b) per day (c) per week (d) per month in the study area A = Shyambazar to Dunlop B = Belgachia to LakeTown C = Rashbehari to Gariahat D = Rabindrasadan to Park Street. And **Table 7** showed a sum up of the data that are presented in **Figure 2**.

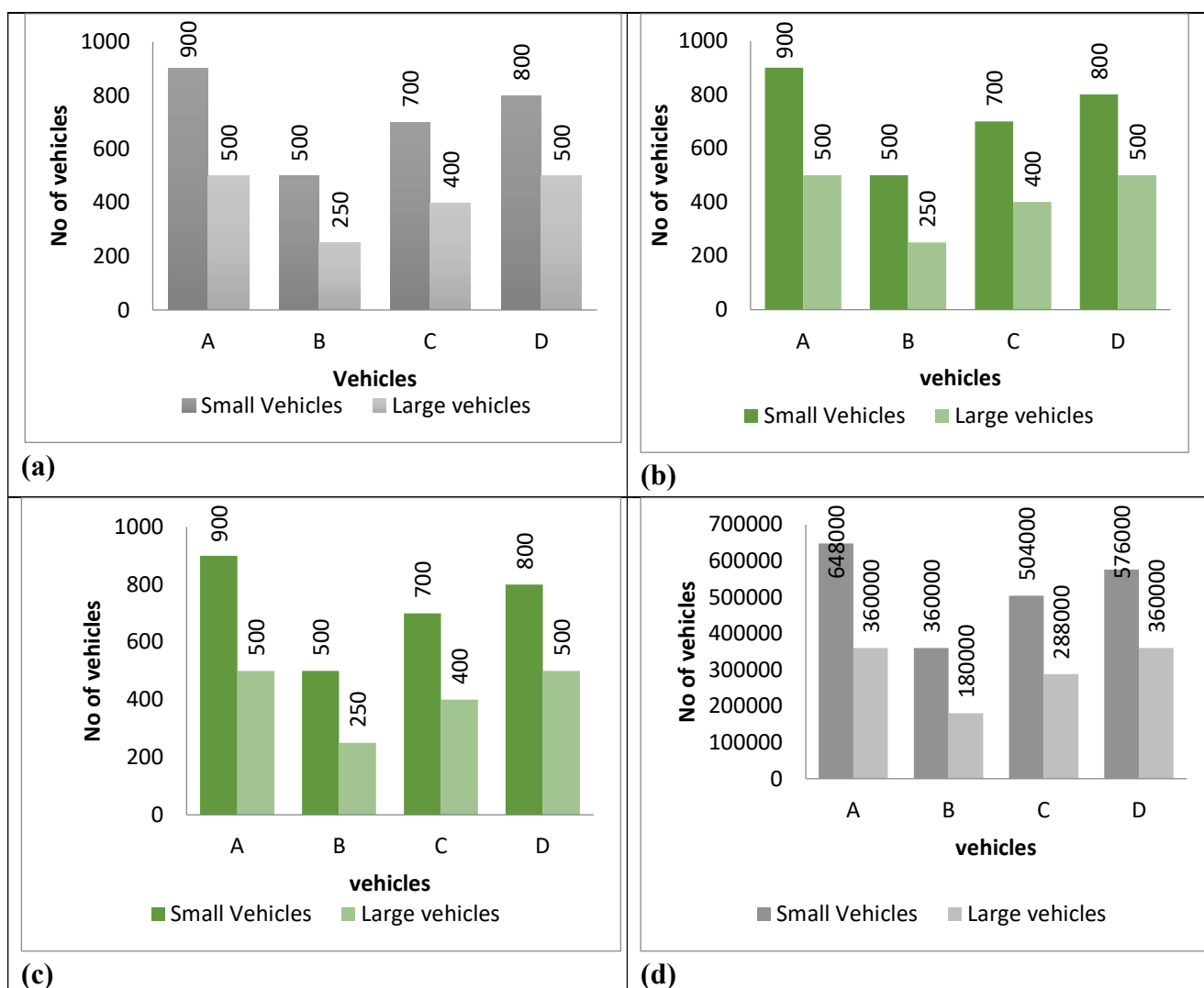


Fig 2 : The average density of vehicles flowing (a) per hour (b) per day (c) per week (d) per month in the study area. Locations are : (a) Shyambazar to Dunlop; (b) Belgachia to LakeTown; (c) Rashbehari to Gariahat; (d) Rabindrasadan to Park Street

Study area	No of small vehicles flowing				No of large vehicles flowing			
	per hour	per day	per week	per month	per hour	per day	per week	per month
Shyambazar to Dunlop	900	21600	157200	648000	500	12000	84000	360000
Belgachia to Laketown	500	12000	84000	360000	250	6000	42000	180000
Rashbehari to Gariahat	700	16800	117600	504000	400	9600	67200	288000
Rabindrasadan to Parkstreet	800	19200	134400	576000	500	12000	84000	360000
Table 7 showed the number of small and large vehicles in the study area per hour / day / week / month								

The total number of the plant species on the both sides of avenues are 120, 65, 85 and 78 in Shyambazar to Dunlop (*location 1*), Belgachia to Lake town (*location 2*), Rashbehari to Gariahat (*location 3*) and Rabindrasadan to Parkstreet (*location 4*). The average distance of the roadside trees from one to another is 11.43 meters in *location 1*, 9.14 meters in *location 2* and 3. In *location 4* it is 6.85 meters approximately. The distance between the plant keeps proportionality with the total number of plants along the road of the locations. In the Table No. And we have included the 11 most abundant plant species that are observed in the four study area and also described some of their morphological facts along with scientific names and families. Unfortunately the condition of these recorded plants alongside the pavement of these study areas are poor in terms of the plant health (**Table 8 – 9**).

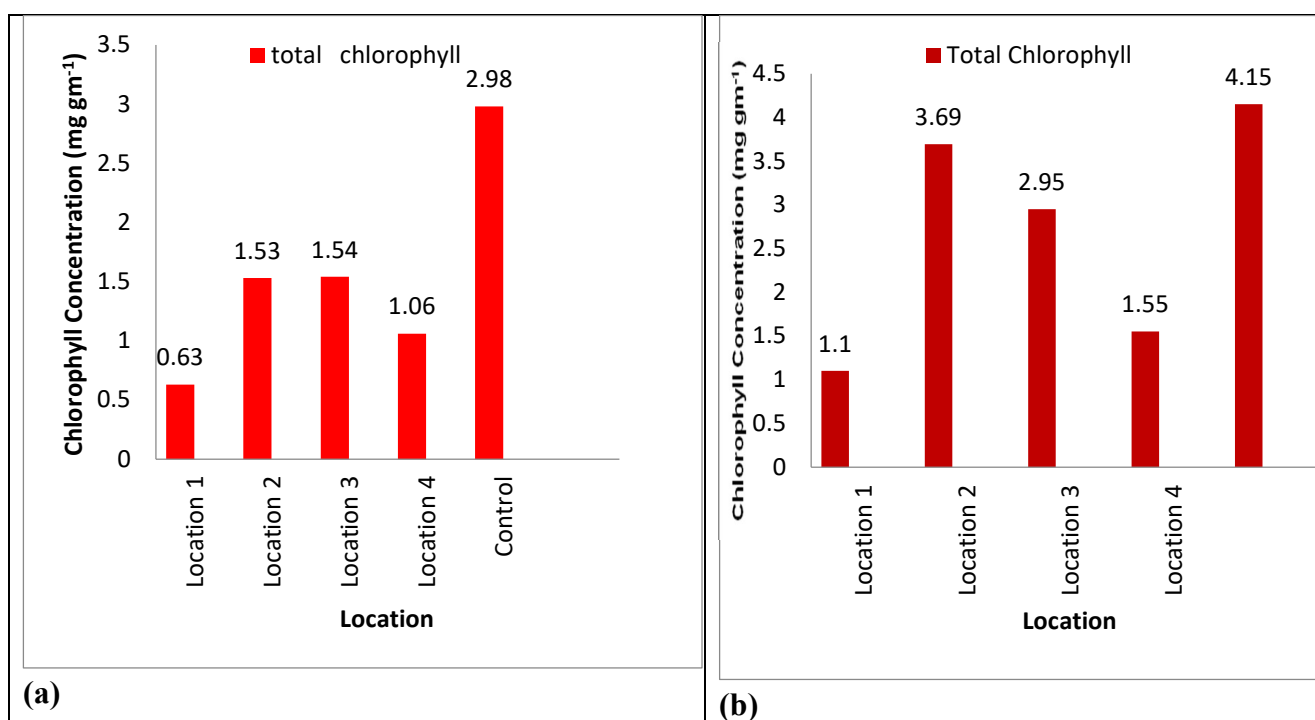
Name of the plant species	Location1	Location2	Location3	Location4
Banyan tree	+	-	+	+
Mango tree	-	-	+	+
Peepal tree	+	+	+	+
Deodar tree	+	+	+	+
Gregarious tree	-	-	-	+
Chatim tree	+	-	+	+
Peacock flower	+	+	+	+
Jarul tree	-	-	-	+
Guava tree	+	+	-	+
Jack fruit	-	+	-	+
Palash tree	+	-	-	+
Table 8. showed the abundance of 11 plant species on the selected study area				

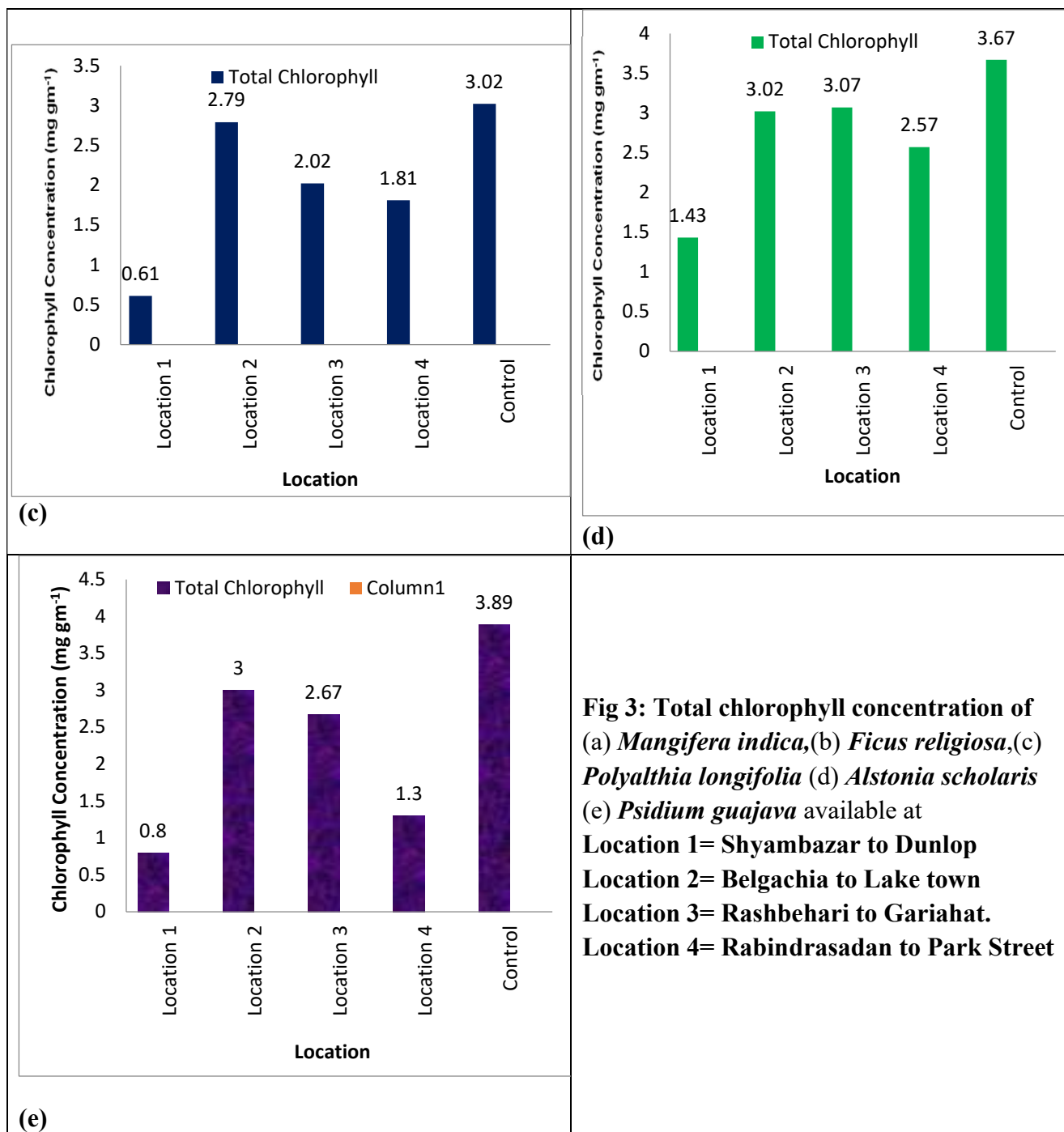
Common name	Scientific name + APTI	Family	Essential Description
1. Mango	<i>Mangifera indica</i> + 18.5	Anacardiceae	Large evergreen , 10-45 m in height, dome shaped with dense foliage , spirally arranged leaves are large.
2.Peepal	<i>Ficus religiosa</i> 7.68	Moraceae	Large dry season-deciduous or semi-evergreen tree up to 98 ft tall , The leaves are cordate in shape with a distinctive extended drip tip; they are 10–17 cm long and 8–12 cm broad, with a 6– 10 cm petiole.
3.Guava	<i>Psidium guajava</i> 6.43	Myrtaceae	Evergreen shrub or small tree, up to 10 m high.. The leaves are opposite and simple, ovate to oblong-elliptic, rounded at the base,
4.Chatim	<i>Alstonia scholaris</i> 13.45	Apocynaceae	Glabrous tree and grows up to 130 ft. tall. The upper side of the leaves is glossy, while the underside is greyish. Leaves occur in whorls of three to ten; The leathery leaves are narrowly obovate to very narrowly spatulate,
5. Peacock flower	<i>Caesalpinia pulcherinna</i> 16.48	Fabaceae	The tree can rise upto 25m and its low branches form an open and spreading bush. It is a shrub growing to 3 m tall. The leaves are bipinnate, 20–40 cm long, bearing 3-10 pairs of pinnae, each with 6-10 pairs of leaflets 15–25 mm long and 10–15 mm broad.
6. Deodar	<i>Polyalthia longifolia</i> 16.66	Annonaceae	Evergreen tree can grow up to a height of 15-20 meters tall , The longest branch is seen at the base and shorter at the end of the trunk, giving an appearance of conical crown. Leaves are long, narrow dark green and glossy. Leaf blades are ovate-oblong to ovate-lanceolate with wavy margins.
7.Gregarious	<i>Dalbergia sissoo</i> 10.669	Leguminosae	Medium to large deciduous tree with a light crown . It can grow up to a maximum of 25 m (82 ft) in height . Leaves are leathery, alternate, pinnately compound and about 15 cm (5.9 in) long.
8. Jarul	<i>Lagerstroemia flosreginae</i> 8.87	Lythraceae	Shrub to large tree with multiple trunks or stems diverging from just above ground level, up to 40(45) m tall and 100(-150) cm in diameter. Leaves opposite, distichous, simple, entire, stipules minute or absent.
9.Palash	<i>Butea monosperma</i> 10.3	Fabaceae	An erect tree with height of 12-15 m and irregular branches bark rough, ash coloured, and young parts downy. The Leaves of plant are 3-foliolate, with 10-15 cm long,
10. Silk cotton plant	<i>Bombax ceiba</i> 35.46	Moraceae	Deciduous trees; to 45 m high , ; branches horizontal and more or less whorled; branchlets prickly. Leaves digitately-compound, alternate.
11.Banyan tree	<i>Ficus benghalensis</i> 21.65	Moraceae	Large, long-lived, fast-growing evergreen tree up to 20 -25 m, tall. It has a wide leafy crown of horizontal branches covering up to 100 m around , The leaves are large, 8-25 cm long x 6-20 cm broad, stoutly petiolated. The lamina is coriaceous, nerved, ovate to obovate in shape. The lamina is glabrous on the upper face and finely pubescent.

Table 9. The morphological features of the plant species with Air pollution tolerance index (APTI) value.

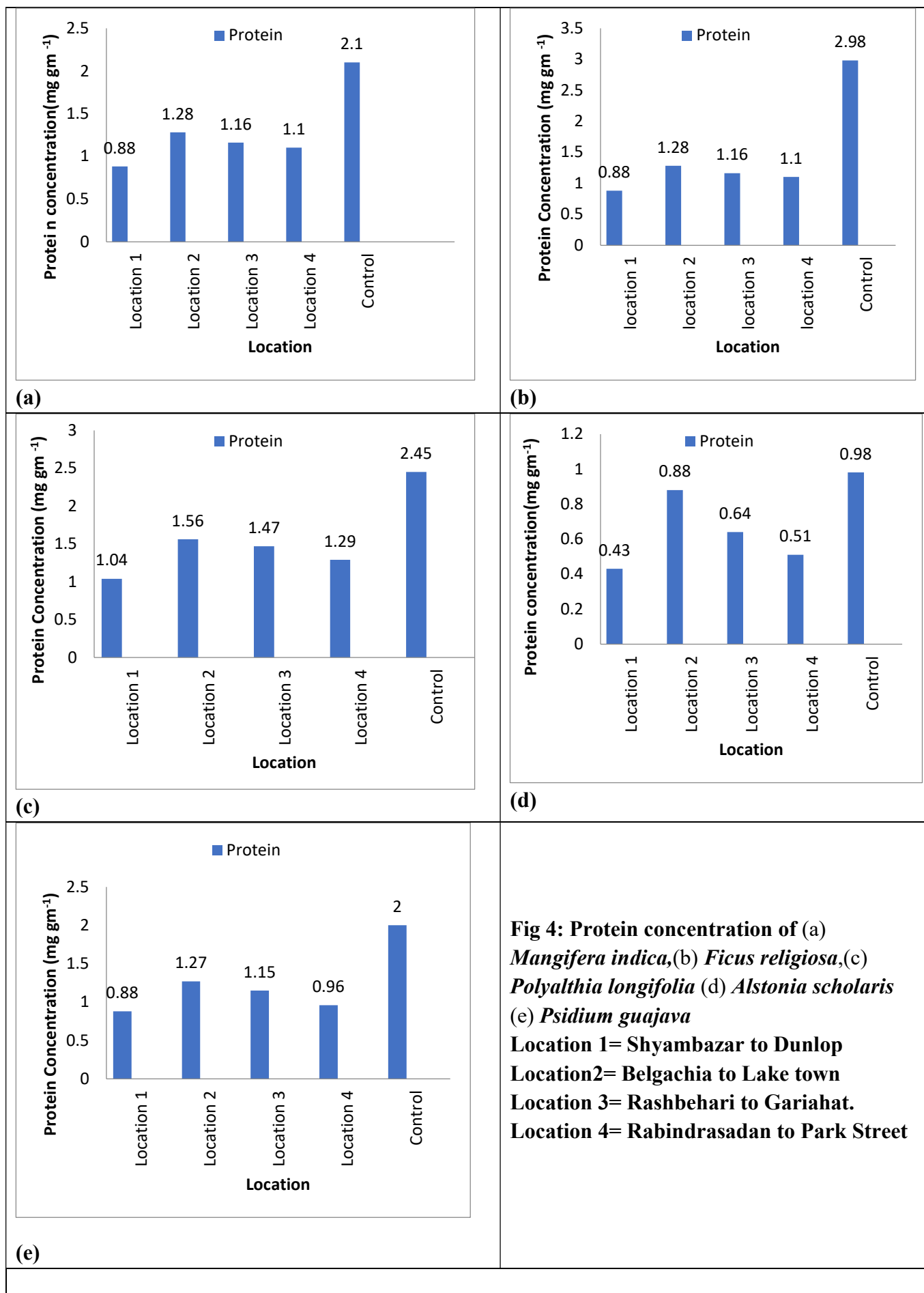
Air pollution tolerant index is an index, which regulates the potentiality of a plant to compete against air pollution. Plants which have higher index value are tolerant to air pollution and can be used as sink to reduce pollution, while plants having low index value show slighter tolerance and can be used to indicate levels of air pollution. *Ficus religiosa* , *Ficus bengalensis* and *Mangifera indica* have high APTI value (Haque, 2017) . The plant species, which are grown up along the road sides and are commercially important, may show as an absorbent of the various pollutants and their study may give the level of pollutants in any specific area of interest Similarly, species with higher APTI should be planted in the areas (Singh, 1983)

High traffic load donates high dust fall on the plant leaves this also depends upon the situation of roads (Lone, 2005) and size and structure of leaves. Maximum decrease in chlorophyll content recorded in location 1 plant species and lowest decrease in chlorophyll recorded in plant species of the location 2 . Reduction of chlorophyll may happen due to the increase of chlorophyllase enzyme activities, which in turn influence the chlorophyll concentration in plants (Mandal et. al., 2000). SO₂ plays an major role in the reduction of chlorophyll content which causes phenopythin formation by acidification of chlorophyll (Mandloi et al., 1988). Reductions in chlorophyll contents of a variety of crop plants due to SO₂ and O₃ exposure have also been reported by Agrawal (Agarwal, 1985). Chlorophyll content is essential for the photosynthetic activity and reduction in chlorophyll content has been used as an indicator of air pollution stress. **Figure 3** showed the chlorophyll a and Chlorophyll b concentration of (a) *Mangifera indica*, (b) *Ficus religiosa*, (c) *Polyalthia guajava* (d) *Alstonia scholaris* (e) *Psidium guajava*





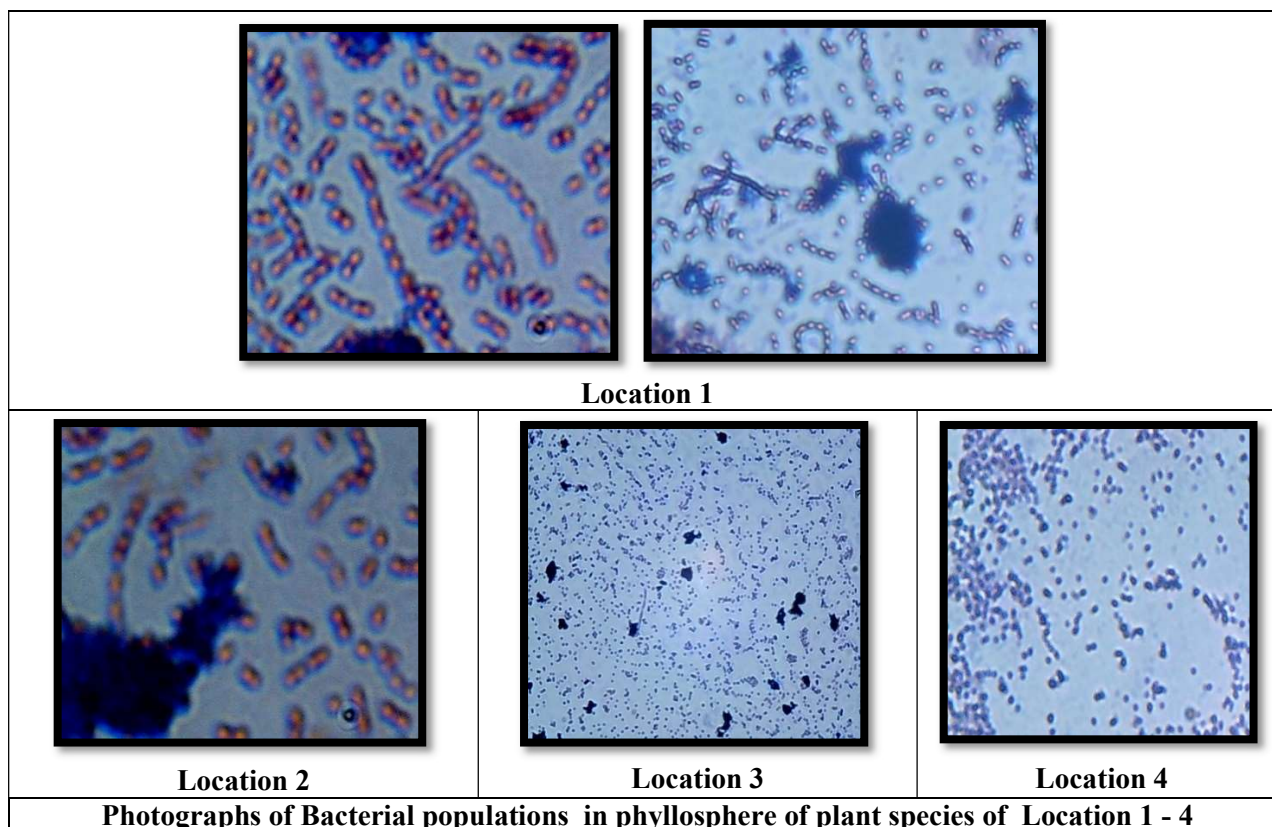
Maximum loss of leaf protein was recorded in plant species from location 1 and minimum loss was found in the plant species of location 2. **Figure 4** showed the protein concentration of (a) *Mangifera indica*, (b) *Ficus religiosa*, (c) *Polyalthia guajava* (d) *Alstonia scholaris* (e) *Psidium guajava*. The protein loss may be due to the effect of automobile emission on plant leaf which absorbs most of the pollutants. Reduction in soluble protein and chlorophyll contents in a few plants as indicators of automobile exhaust pollution (Banerjee et. al. 2007).



The plates were observed after the 2 days of incubation for appearance of colonies over the agar surface. The *Azotobacter* colonies appear flat soft mucoid and milky which are N₂ fixing bacteria and the starch degrading bacteria were found in the four location sites. The plates were examined for the starch hydrolysis around the line of growth of the organisms. Typical positive starch hydrolysis reaction surroundings the microbial colonies were shown by the production of exoenzyme amylase which was diffused into the medium surrounding growth. Phosphate solubilising bacteria was also found on the location 1 and 4. **Bacterial count on phyllosphere: Table 10.** The number of bacterial colonies in agar medium is maximum at shyambazar to Dunlop area (location1) where as the number of colonies is minimum in the Belgachia to Laketown (location 2). It may be for the turbulence of air at location 1, the bacterial count showed maximum population. .

Water collected from the leaves surface of the study area	Dilution	Medium	Colony count after 24 hours	Colony count after 72 hours
Shyambazar to Dunlop (location1)	10 ⁻³	Nutrient agar	203	300
	10 ⁻⁴	Nutrient agar	179	252
	10 ⁻⁵	Nutrient agar	77	168
Belgachia to Lake town (location 2)	10 ⁻³	Nutrient agar	170	200
	10 ⁻⁴	Nutrient agar	160	184
	10 ⁻⁵	Nutrient agar	122	165
Rashbehari to Gariahat (location 3)	10 ⁻³	Nutrient agar	188	272
	10 ⁻⁴	Nutrient agar	150	228
	10 ⁻⁵	Nutrient agar	116	212
Rabindrasadan to Park street (location4)	10 ⁻³	Nutrient agar	186	262
	10 ⁻⁴	Nutrient agar	135	220
	10 ⁻⁵	Nutrient agar	112	198
Table 10: Showed the results of the number of microbes on each study area				

Bacterial association was evident by microscopy on the phyllosphere of selected plant species of heavily vehicular polluted zone, which indicated its sensitivity to the dust as well as microbial population adheres on the surface of the leaves on dust. . Stomata generally act as a direct passage for water transportation. Covering of stomata with dust causes the disturbance in the transpirational processes. An extensive and further research is needed in this area to describe the proper mechanism of the interaction of air pollutants and microbial association.



Highest number of seeds were germinated by the leaf water leachates of location 2 (Belgachia to Lake town) and the lowest seed were germinated in location 1 (Shyambazar to Dunlop). This indicates the extreme presence of leaf surface pollutants in location 2 in comparison to the location 1. **Table 11** showed the percentage of inhibition of the seed germinated on each location of the study area.

	1 st DAY		2 nd DAY		3 rd DAY	
	<i>Cicer</i>	<i>Vigna</i>	<i>Cicer</i>	<i>Vigna</i>	<i>Cicer</i>	<i>Vigna</i>
Control	10	10	10	10	10	10
Shyambazar to Dunlop	4	5	5	5	5	5
Belgachia to Laketown	6	5	7	5	7	5
Rashbehari to Gariahat	5	4	5	4	5	5
Rabindrasadan to Parkstreet	7	5	7	6	7	6

Table 11. Showing the germination of seeds of *Cicer* (Gram) and *Vigna* (mung) by number in comparison to control. The seeds were treated by wash out water of the leaf surface of the randomly selected plant from 4 study areas. The control seeds were treated by the wash out of the leaves of plant collected from Bhadreswar , Hooghly , a rural area. The seeds were incubated for three days in an incubator (27 degree celcius)

Conclusion

We live in an age of vehicles. Vehicles have raised our potency, increased our efficiency and have added to a substantial loss of the cost in transition also by saving time. However , increase in vehicular population has its adverse effect. The emission from vehicles has degrade our environment. Of course, the faulty road structure and congestion have complicated the issue. The increase in number of vehicles

and the impact of their emission have direct effect on the avenue plants which suffer from toxicity as induced by air pollutants. The phyllospheric study of the plants, the condition of the road side plants under continuous emission, their detrimental change on the primary metabolites are to be seriously discussed. The health, growth and development of road side plants which may absorb a considerable amount of air pollution are at a stake in the city of Calcutta. The concept of clean and Green city may get interruption when our study showed the actual situation.

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COVID-19 Pandemic: *Ex-concurrent* and *Ex-post* Transformations

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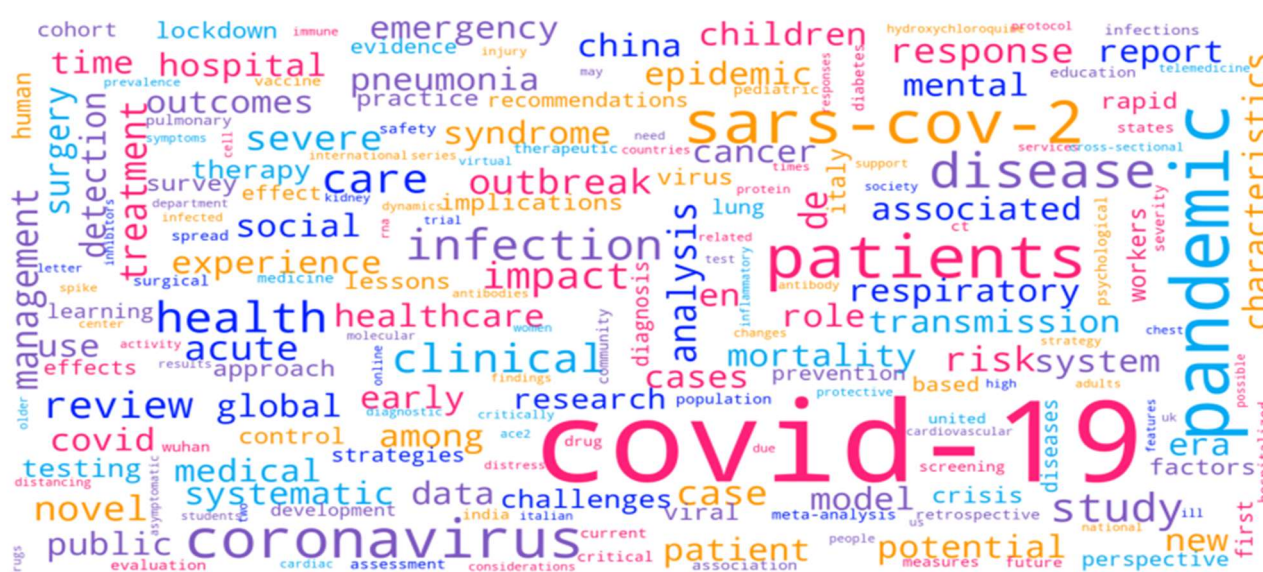
Abstract:

The COVID-19 pandemic can be traced back to the most frequent key words in article titles tagged as COVID-19. Pandemic refers to the uncontrolled outbreak of an epidemic that emerges following the spread of the virus all over the world. It is all about the massive disruptions that have taken place at many levels from the economic fields to Cultural fields. It also refers to the helplessness of the human ingenuity before the ingenuity of the nature. Already, at the time of typing this article, globally 171,708,011 people have been affected and 3,697,151 have been pronounced dead. So, the story of global pandemic was the story of anxiety, suffering, disease and death of the less fortunate people. The global pandemic is not merely a medical phenomenon; rather it pervades the entire field of human activities including economy, culture and ecology. Novel Corona Virus (COVID-19) has brought about “novel” changes in the ambience of trade and commerce, culture and ecology. These waves of changes are creating economic, cultural and ecological impacts. The objective of our discourse is to provide a snapshot about the extensity, intensity and propensity of the impacts of COVID-19 pandemic.

Key Words: *economic, cultural, ecological, impacts, disruptions, pandemic, COVID-19.*

I. Global Pandemic

Let me start with the most frequent key words in article titles tagged as COVID-19 ¹.



Most frequent words in article titles tagged as COVID-19

My reason of starting with the most frequent key words in article titles tagged as COVID-19 is to highlight the fact that the intensity, extensity and propensity of the COVID-19 Pandemic can be traced back to them. Pandemic refers to the uncontrolled outbreak of an epidemic that emerges following the spread of the virus all over the world. It is all about the massive disruptions that have taken place at many levels from the economic fields to Cultural fields. It also refers to the helplessness of the human ingenuity before the ingenuity of the nature. The human existence is under severe threat. Already, at the time of typing this article, 171,708,011 people have been affected and 3,697,151 have been pronounced dead (spreading over 224 countries and areas)² (WHO Coronavirus (COVID-19) Dashboard: 4 June 2021).

The story of global pandemic is the story of anxiety, suffering, disease and death of the less fortunate people. The global pandemic is not

People Affected	Pronounced Dead	Countries and Areas Affected	Dashboard Dated
754,948	36,571	202	³ (31 March 2020)
2,074,529	139,378	213	⁴ (17 April 2020)
3,349,786	238,628	213	⁵ (3 May 2020)
171,708,011	3,697,151	224	² (4 June 2021)

merely a medical phenomenon; rather it pervades the entire field of human activities including economy, culture and ecology. Novel Corona Virus (COVID-19) has brought about “novel” changes in the ambience of trade and commerce, culture and ecology. These waves of changes are creating economic, cultural and ecological impacts. These multiple impacts are in turn affecting us with both positive and negative externalities. Thus, the matter merits discussion from many angles. Logically, we are supposed to perform the study before the outbreak (i.e., *ex-ante*) and during the outbreak (i.e., *ex-concurrent*) and after the outbreak (i.e., *ex-post*) of the COVID-19 pandemic. Consequently, we do require a cut-off period of the outbreak of the COVID-19 pandemic. As per media reporting, the outbreak has begun in Wuhan, China, in December, 2019. However, the COVID-19 disruptions have started in India since the imposition of countrywide lock-down on 1.3 billion people since 24th March, 2020. The successive periods of Lockdown have a deep impact on India’s economy, society, polity and ecology. The objective of our discussion is to provide a snapshot about the *Ex-anti*, *Ex-concurrent* and *Ex-post* transformations due to COVID-19 pandemic.

II. *Ex-ante* Scenario

World merchandise trade volume was expected to be affected so adversely that it was predicted to go down even beyond the global financial crisis of 2008-09. (Press Release, 8 April, 2020, WTO). According to the McKinsey’s latest survey ⁶ (December 2019) on economic conditions, growing section of respondents has portrayed somewhat optimistic picture. In terms of the global economy, the respondents’ views have remained unchanged about the trade conflicts, geographical instability and changes in trade-policy. However, in terms of respondents’ home economies, their views have been shifted to changes in trade-policy, domestic political conflicts and geographical instability. The aforesaid findings are corroborated by the observations of IMF Blog ⁷ (December 18, 2019). According to the blog, rising trade barriers and associated uncertainty has been responsible for cyclical and structural slowdowns globally. Further pressures came from country-specific weakness in large emerging market economies such as Brazil, India, Mexico, and Russia. Worsening macroeconomic

stress related to tighter financial conditions (Argentina), geopolitical tensions (Iran), and social unrest (Venezuela, Libya, Yemen) rounded out the difficult picture.

III. *Ex-concurrent and Ex-post Scenario*

The outbreak of (COVID-19) has medical root and economic consequences. During the lockdown there is a total economic disruption. Erosion of the GDP, increasing pressure of NPA, joblessness of daily-wage workers, hoarding of essentials, losing of jobs, govt. dictated food rationing, death due to hunger etc are some of the direct economic scenarios of COVID-19. The scenario is quite evident from Moody's GDP forecast ⁸ (March 28, 2020). Moody's Investors Service sharply cut India's GDP forecast to 2.5% during the lockdown, which was 5.3% before the lockdown. According to "Business Today" estimate ⁹ (March 27, 2020), Indian economy may lose Rupees 8.76 lakh crore during the period of lockdown (Table 1) ¹⁰ (March 27, 2020). Sex-workers in Mumbai are struggling to survive amid coronavirus-lock-down ¹¹ (Mar 29, 2020). Overall, it appears that the economic situation is becoming very gloomy and day after day the economic transformation are depicting frustrating picture. Disruptions caused by the global pandemic (COVID-19) has cultural (i.e., ethical, social and political) consequences.

Thus, it also has brought into focus the power of culture in this global pandemic (i.e., the power to save the mankind by practicing alternative culture). An offshoot of the current global pandemic is digital

Table – 1		
Sector	Degree of disruption	Estimated Loss (Rs. lakh crore)
Mining & Quarrying	Complete	0.31
Manufacturing	Near Complete	2.16
Construction	Complete	1.06
Trade, Hotel, Transport, Communication	Near Complete	2.42
Financial, Real Estate, Professional Services	Near Complete	2.81
		8.76

transformation. A global survey of 800 executives across eight industries conducted by The Economist Intelligence Unit has highlighted the need for digitization. Digital transformation could impact most positively the broad societal areas like skill building, diversity & inclusion, public Health & welfare, public safety, disinformation, energy security, unemployment, climate change, food security, wealth inequality and disaster relief¹². The mining sector has been affected adversely due to the fall in demand and the consequent fall in the prices of metals and minerals. ¹³ (2020).

IV. Pandemic (Indian Scenario: at the nascent stage)

I have made an analysis of the nascent stage with the help of the COVID-19-Patient Database of India available through (COVID19-India: Patient Database: 31/03/2020 at 11.44 a.m. <https://t.me/covid19indiaops>).

i) Analysis

Form the analysis (Table -2), it appears that transmission through overseas connection was one of the most prominent features of the COVID-19 crisis of India. i.e., out of 1585 patients

Table – 2		
Mode of Transmission of COVID-19 infection in India	Number of Patients infected with COVID-19	Total
Local	405	1585
Imported	511	
Yet To Be Determined	656	
Data not available	13	

so far identified 511 patients were of foreign nationality. It appears that “cultural extension activists and activities” do matter.

Further, it appears that Tourist, Travelling to Foreign Countries, Travel History and Returning from Foreign Country were the key factors for the spreading of COVID-19 infections in India (Table -3). In the following paragraphs, analysis has been done regarding the other dimensions: e.g., deceased rate, recovery rate of patients (imported) in comparison with recovery rate of patients (local) etc.

From (Table -4), it appears that deceased rate almost remaining the same.

Recovery rate for patients (imported) is better than Patients (Local).

From (Table 5), it appears that the two highly affected states (Kerala and Maharashtra) have large number of patients (imported) in comparison to Patients (Local).

From (Table 6), it appears that the male and the female both segments have large number of patients (imported) in comparison to Patients (Local).

From (Table 7), it appears that (within Age Group 1-17 Years) the male and the female both segments have large number of Patients (Local) in comparison to patients (imported). From (Table 8), it appears that (within Age Group 18-25 Years) the male and the female both segments have large number of patients (imported) in comparison to Patients (Local).

Table -3

Key Factors for the spreading of COVID-19 infections in India	No. of Patients infected with COVID-19	
	Local	Imported
Tourist	-	31
Doctor	4	2
Travelling To Foreign Country	-	24
Travel History	-	68
Returning From Foreign Country	-	78
Wife Of Infected	5	4
Mother Of Infected	5	-
Father Of Infected	3	2
Daughter & Daughter-in-Law	7	-
Son & Son-In-Law	5	1
Family Members	10	3
Relative & Close Relative	17	-
Others/Data not available	349	298
Total Number of Patients infected with COVID-19	405	511

Table - 4

	Migrated	Hospitalized	Deceased	Recovered
Local	-	389	7	9
Imported	1	453	11	46

Table - 5

Number	Kerala Imported/Local	Maharashtra Imported/Local	Karnataka Imported/Local	Tamil Nadu Imported/Local
Patient	160/31	61/37	56/43	25/41
Recovered	14/6	2/ NIL	5/3	2/ NIL
Deceased	1/NIL	2/ NIL	2/1	NIL /1
Hospitalized	145/25	57/37	49/39	23/40

Table - 6

Number	Patients (imported)		Patients (local)	
	Female	Male	Female	Male
Patient	113	276	99	184
Recovered	5	21	6	4
Deceased	3	8	2	5
Hospitalized	105	247	91	175

Table - 7

Age 1-17 Yr	Number of Patients (imported)		Number of Patients (local)	
	Female	Male	Female	Male
Patient	1	2	9	7
Recovered	NIL	1	1	NIL
Deceased	NIL	NIL	NIL	NIL
Hospitalized	1	1	8	7

Table - 8

Age 18-25 Yr	Number of Patients (imported)		Number of Patients (local)	
	Female	Male	Female	Male
Patient	21	56	8	26
Recovered	1	4	-	-
Deceased	-	-	-	-
Hospitalized	20	52	8	26

From (Table 9), it appears that (within Age Group >65 Years) the male and the female both segments have large number of patients (imported) in comparison to Patients (Local). It appears that the male and the female

Table – 9				
Age >65 Yr	Number of Patients (imported)		Number of Patients (local)	
	Female	Male	Female	Male
Patient	12	21	10	10
Recovered	1	3	-	1
Deceased	2	6	1	2
Hospitalized	9	12	9	7

both segments have large number of patients in the age group 18-25 Years in contrary to the widespread prediction that children and the elders are most vulnerable.

ii) Comments

From above analysis, it appears that the culture is the most prominent factor of global disruptions like COVID-19 pandemic which is quite evident from the large number of patients having infected by COVID-19 through imported mode of transmission rather than local (Table-2 a).

Here lies the significance of culture including the society and polity in the present discussion. Even the very name “COVID-19” itself is the product of

Table – 2 a	
Mode of Transmission of COVID-19 infection in India	Number of Patients infected with COVID-19
Local	405
Imported	511

cultural reservations. “We had to find a name that did not refer to a geographical location, an animal, an individual, or a group of people, and which is also pronounceable and related to the disease,” said Tedros Adhanom Ghebreyesus, the director-general of the WHO, during a press conference ¹⁴ (Feb 14, 2020). We are staying in so that COVID-19 stays out. It is really very unusual and painful to be confined in home for 24 hours. We are in a fix about how to utilize the never-ending time. However, we are redesigning and redefining ourselves by engaging in different household chores for the first time in our lives. In fact, people tend to become more social internally and externally during the lockdown. We are sure that our fight with the COVID-19 is going to be a long-term agenda and we do require to carry on our collective discipline and conviction regarding hygiene etiquette even after the end of the lockdown.

V. Transformations

The COVID-19 pandemic is in many respects unprecedented, but in no respect it was unforeseen. As we focus on our immediate collective response, it is vital that we learn from the mistakes, missteps and missed opportunities of the past if we are to avoid repeating them ¹⁵ (2021).

a) Social

The transformation through disruptions on account of COVID-19 pandemic vary cross-culturally. Therefore, we need to understand transformation discussion, within the context of culture. Let us explore the existing literatures.

In a unique case of social ostracism, the migrant workers returning to villages were told to live in trees to enforce social distancing Later it turned out that the behaviour of the villagers is pro-active reaction. They had taken the media campaign about social distancing seriously enough to ask the workers to make trees their home during the self-quarantine ¹⁶ (Mar 29, 2020). Another interesting development is that usage of different social media has been increased sharply. 70% more people are using group video calls and are spending more time than usual watching Facebook and Instagram Live amid the new

coronavirus pandemic ¹⁷ (24 Mar, 2020). WhatsApp has seen a 40 % increase in usage. Across all stages of the pandemic, WhatsApp is the social media app experiencing the greatest gains in usage as people look to stay connected ¹⁸ (28 Mar, 2020). An engineering professor at Algeria's University of Oran and a human rights activist said that because of the novel coronavirus pandemic, confinement is an additional punishment for the prisoners ¹⁹ (April 17, 2020). Inspectors who visited two closed women's prisons found there was an urgent need to ease severe COVID-19 restrictions because many prisoners reported deteriorating physical and mental health and some had not seen their children for long time. ²⁰ The currency of fame has always been deeply unstable. Apparently, through smart phones, the famous people are suddenly on the same footing as everybody else during the closure of movie theatres and live venues. Despite this illusion of a level playing field, the famous are finding new ways into our minds and are appearing in unfamiliar ways ²¹ (Jun. 11, 2020). Our culture leans so sharply toward the social that it rewards social behaviour while ignoring the positive effects of time spent alone ²² (Apr. 19, 2017). The American Psychological Association's annual convention, 2017 focused on data that reveals loneliness and social isolation pose an equal, if not greater, danger to public health than the more commonly discussed risk factors such as smoking, obesity etc. We are lonelier today than at any other point in recorded history and there is an impending danger of outbreak of loneliness epidemic. ²³ (Dec. 26, 2017). The World Wide Web has started to reflect what its inventor, Tim Berners-Lee, imagined - a collective of ideas shared not for glory or financial gain but for the betterment of human knowledge. Zoom offering free upgrades for schools, Canadian telecommunications businesses waiving roaming and long-distance fees and Uber delivering food to health care workers for free, the digital ecosystem is seeing a boom of organizational altruism. ²⁴ (April 29, 2020). Our devices are delivering a culture of auto-romance. Invisible Boyfriend or Invisible Girlfriend who pretend to be your romantic partner offer companionship and conversation. Hence, the online community is providing millions with illusions of intimacy. ²⁵ (Jan. 2, 2020). Everyday creativity has been boosted as a means to relieve the stress, anxiety and depression caused by the pandemic. ²⁶ (February 2021). From the personal to the professional, the role of beauty has changed overnight. 82 per cent of women are currently wearing less make-up, with 52 per cent of us having changed our beauty priorities since lockdown began. With the lower half of the face covered, the eyes will take on a new importance, with focus on the eyes and brows and bold eye looks used to express individuality. ²⁷ (May 15, 2020). The clients have adopted digital fitness solutions to counter the physical restrictions posed by the pandemic. The extended lockdown drove a massive surge in the demand for virtual classes for yoga (87%) and high-intensity interval training (HIIT) cardio workouts such as zumba (72%), aerobics (67%), and pilates (22%) ²⁸. Anthropologist Edward Hall coined the term proxemics and described public distance, social distance, personal distance and intimate distance as distinct categories common to all cultures. However, social distancing measure during pandemic refers to the distances covered by droplets and small particles, potentially containing viral loads, when breathing, coughing or singing ²⁹. The Oxford COVID-19 Government Response Tracker with daily information on travel and movement across 111 countries, finds that autocratic regimes imposed more stringent lockdowns. However, no evidence is found that autocratic governments were more effective in reducing travel. Rather, democratically accountable governments introduced less stringent lockdowns but were approximately 20% more effective in reducing geographic mobility at the same level of policy

stringency. ³⁰ (May 13, 2020). During the pandemic, we have got an opportunity to showcase the relative strengths and weaknesses of democracies and autocracies as a political structure for the management and prevention of pandemic. ³¹ (December 2020). China has reportedly resolved the pandemic situation swiftly even in the face of international condemnation for spreading COVID-19 epidemic from Wuhan. ³² (2020). From implementing sanitizer stations to increasing signage to maintain physical distance, some of the largest hotel brands have raised their cleaning standards in the wake of the coronavirus pandemic. ³³ (May 13, 2020). During the pandemic, many employers and employees have demonstrated exceptional adaptability in shifting their place of work from the office to the home. ³⁴ “Deepfakes” has turned out to be the new digital-social menace. Deep learning process is used to train an algorithm to doctor a fake scene. Deepfakes now require no working knowledge of AI-enabled technology. All it takes is some sample footage and a large data set of photos and the free software like FakeApp or Faceswap which can convincingly swap out one person’s face for another’s. ³⁵ Very often the banks alert us about social engineering fraud using mobile numbers similar to bank’s toll-free number to obtain pin, CVV, ID, Password etc. The term social engineering fraud is also important in the context of the cash-less transactions and crypto-currency transactions which are being used now in ever-increasing haste. Recently, a supermajority of the El Salvadoran legislature voted to adopt bitcoin as legal tender. ³⁶ (Jun. 10, 2021). In a global survey of 800 executives across eight industries, respondents from the education sector are most likely to agree that the pandemic has highlighted the need for digitisation to benefit disenfranchised groups in society ³⁷. While enforcing restrictions, some governments have used “friendlier” strategies and some governments have resorted to rather scare tactics or “fear appeals” (coined by Howard Leventhal). However, the ethics of fear appeals needs to be scrutinized in order to determine whether scare tactics are morally acceptable and appropriate ³⁸. The trends of incident cases, deaths, and intensive care unit admissions (ICU) in Spain and Italy before and after their respective national lockdowns using an interrupted time-series design was analysed. Results reveal that during the successive lockdowns the epidemic curve has been flattened and confirmed that lockdown was effective. ³⁹ (2020 July). It was found that the SutteARIMA method is more suitable than ARIMA to calculate the daily forecasts of confirmed cases of Covid-19 in Spain. ⁴⁰ (2020). A mathematical model applied for a population of 100,000 provides an overview to improve knowledge of outbreak trends and quarantine effectiveness in reducing infection. Results reveal that the decrease in infected people is due to the quarantines. ⁴¹ (2020). The implementation and outcomes of telemedicine (to reduce the risk of transmission) in a Department of Urology in a regional hospital in Northern Italy during the outbreak of Covid19 pandemic was assessed. ⁴² (2020 June). Guidance has been provided to prepare for the impact of COVID-19 pandemic on breast cancer patients and to advise on how to triage, prioritize and organize diagnostic procedures, surgical, radiation and medical treatments. ⁴³ (2020 Aug). A conceptual model was proposed for the COVID-19 outbreak in Wuhan with the consideration of individual behavioural reaction and governmental actions. ⁴⁴ (2020 Apr). Globally or locally, physical interaction between Doctor and Patient has been replaced by online consultation with the Doctors. Virtualised treatment has become the way of our lives at the cost quality of clinical care to some extent. ⁴⁵ (April 11, 2020). The home-confinement during lockdown has reportedly deteriorated mental and physical health conditions. ⁴⁶ (2020 June). During lockdown, 1.3

billion people in India, 760 million in China, more than 200 million in the USA and 300 million in Europe and UK were ordered to stay inside. The home-confinement has reportedly facilitated sexual intimacy through increased time spent together and simultaneously offset the intimacy due to the more chance of interpersonal conflicts and stress. ⁴⁷ (2020 Apr 30). The home-confinement during pandemic has reportedly aggravated chaos, fear, anxiety, stress and disrupted cognitive functions. ⁴⁸ (2020 Apr 11). The psychological distress perceived by the Italian general population during the early phase of the pandemic was investigated. The study has provided important insight into developing targeted intervention strategies. ⁴⁹ The home-confinement during lockdown implicitly imposed restricted mobility for all including the very old people. Compulsive immobile lifestyle over the months has reportedly damaged the mobility capacity of the very old people permanently. ⁵⁰ (2020). It has been transpired that the country-wise lockdown is important to prevent the spread of COVID-19 among Italian population. ⁵¹ Decrease in the workforce as well as in the demand has been perceived on extraction of raw materials, production of finished products and service provision industries due to social distancing and travel restrictions. However, people have resorted to panic-buying in case of medical supplies and food. ⁵² The month-long lockdown has reportedly deteriorated glycaemic control and diabetes related complications. Consequently, it has increased co-morbidity factors associated with COVID19 infection. ⁵³ (2020 Jul-Aug).

b) Ecological

It has been observed that the global ecology has been significantly improved during the month-long or rather year-long lockdown imposed in different parts of the world.

Let us explore the existing literatures.

Lockdown has served as an air purifier. BHIWADI has made a giant leap forward from poor to good on a long scale of poor-moderate-satisfactory-good. With most vehicles off the roads, flights grounded and all but essential businesses shut, people in some of the world's biggest cities appear to be breathing air with relatively safer levels of pollutants. According to the "Indian Today" ⁵⁵ (March 27, 2020)

Table-10			
City	Air Quality Index Last year (25-27 Mar 2019)	Air Quality Index before Lockdown (16-24 Mar 2020)	Air Quality Index During Lockdown (25-27 Mar 2020)
Bhiwadi	221 -Poor	207 -POOR	42 –Good
Gaziabad	168 -Moderate	188 -Moderate	81 –Satisfactory
Noida	141 - Moderate	152 -Moderate	71 -Satisfactory

According to the India Today Data Intelligence Unit (DIU), air quality in major Indian cities has been significantly improved during the period of lockdown (Table-10) ⁵⁴ (March

28, 2020). Delhi along with Mumbai, Ahmedabad and Pune have recorded "satisfactory" air quality rating. Weather maps have indicated that pollution over India is considerably lower this year than it was last year. ⁵⁶ (Mar 30, 2020) The weather maps depict less polluting matter in the atmosphere. Dolphins have returned to Italy's coastline, while the famous Venice canal now has become clear enough for us to spot fish ⁵⁷ (Mar 19, 2020). Studies have revealed that there is a positive correlation between air pollution and COVID-19 infection. It indirectly recognises the positive role of lockdown in preventing the spread of COVID-19. ⁵⁸ (2020 Apr 15). Environmental indices have revealed that air quality has been improved during the prevalence of lockdown due to the lower emissions of NO₂, CO₂ and the particulate matters in air. ⁵⁹ (2020). Studies has established that the air quality of the city of

Barcelona (NE Spain) has been improved remarkably during the prevalence of lockdown due to the lower traffic emissions in the air ⁶⁰ (2020 Apr 11). The COVID-19 infection rate in India has remained considerably lower due to quick imposition of restrictive administrative measures. ⁶¹ (2020 Apr 23). Studies have revealed that the air quality of Vembanad Lake, Kerala (the longest freshwater lake in India) has been improved remarkably due to the lower emission of the suspended particulate matter during the prevalence of lockdown. ⁶² (2020). Studies has revealed that there is a significant reduction in CO and NO₂ levels due to the partial lockdown measures implemented in the city of Rio de Janeiro (Brazil). Obviously, it is an instance of improvement of air quality during lockdown. ⁶³ (2020). The National Air Quality Index of the megacity Delhi has revealed that the air quality has been significantly improved during the prevalence of lockdown. ⁶⁴ (2020).

On the whole, the ecological transformation during and after the lockdown are very encouraging and a step forward towards sustainable development.

c) Technological - Developing Global Cloud Culture

During the lockdown, increasing number of people has started taking recourse to the cloud-based culture for social (socializing with friends and relatives), official (discharging official duties and responsibilities), professional (rendering professional services) or for even personal purposes (ordering for groceries or medicines). Even, WHO is rethinking to replace the term “social distancing measures” with the term “physical distancing measures”. The rationale behind this is that in order to prevent community infection, people need to isolate themselves “physically” not socially; they need to stay at home but by no means that should be taken to mean to cut relationships with their friends and relatives. In this cloud-based communication culture we do not need to present us physically for socializing with others. The very controversial “social media” turns out to be the one and only one savoir of mankind for maintaining social relationships.

Let us explore the existing literatures.

The pandemic simply erased many in-person jobs. The people are supposed to acquire digital skill to survive in the new hybrid digital reality. Every job is in some way a digital job and everyone needs to have the basics of digital fluency. COVID-19 was like pouring gasoline on the digital transformation. Technology is growing and evolving so fast and the cloud computing is the only future. ⁶⁵ The Access to COVID-19 Tools (ACT) Accelerator is a time-limited global collaboration designed to rapidly leverage existing global public health infrastructure and expertise to accelerate the development, production, and equitable access to COVID-19 tests, treatments, and vaccines in order to expedite the end of the acute phase of the COVID-19 pandemic. ⁶⁶ (6 April 2021). The COVID-19 Strategic Preparedness and Response Plan (SPRP) outlines the public health measures that need to be taken to support all national governments to prepare for and respond to COVID-19. ⁶⁷ (2020). Researchers all across the world are coming up with new inventions to help tackle coronavirus. COVID-19 is demonstrating what human ingenuity is capable of in the face of adversity ⁶⁸. An improved technology using Raman spectroscopy has been introduced for detection of current and past COVID-19 infections during the analysis of saliva. ⁶⁹. The empirical results provide evidence of strong spill overs across the cryptocurrency markets with respect to global risk factors of COVID-19. ⁷⁰ (2021). As COVID-19 continues to disrupt construction, companies have continued to prove their resiliency through onsite

and offsite innovation and quick adaptation to change. This extenuating circumstance caused construction companies bound by paper documents to be introduced to the power of the cloud. Tools like Microsoft OneDrive, Google Drive and Dropbox are now in wide use across the sector.⁷¹ (May 6, 2020).

VI. End Note

Ex-post sociological transformations have reiterated the importance of the incorporation of online teaching at every level of education. Digital education meanwhile, holds out the promise of opening up educational resources to the students in general. However, the real success of digital education is subject to the dedication of the teachers, access to the necessary technology and internet connectivity to participate on the part of the students. Preparing and delivering the quality lectures online to the students get frustrated due to the deficiencies on the part of the teachers in using effectively the tools and resources associated with the online teaching. The teachers in general are averse to lifelong learning. This does not come as a surprise as the teachers in general have historically been slow to adopt new technologies. COVID-19 has changed that trend slightly. Interestingly, the same teachers are super-fast in learning the SOP of different social media including Facebook and WhatsApp. Naturally, during the period of pandemic, the teachers are under stress as they are proverbially shy in using online teaching gadgets and web resources. Moreover, in the remote areas, the teachers get handicapped due to the poor or no internet connectivity. So far as home confinement during lockdown is concerned, sociological imagination is yet to capture the tolerance level of the citizens during the period of preventive confinement due to COVID-19.

Ex-post ecological transformations have vetted that during the prevalence of lockdown, pollution level in cities across the countries has been significantly improved. Environment impact analysis is yet to calculate the positive correlation between pollution control and lockdown when there are no meteorological interferences.

Ex-post technological transformations have explicitly announced that digital transformation is the hallmark of the new normal. Speed of technological change and integrating new technology into legacy systems are the primary challenge to implement organisation's digital transformation strategy. By default, the cloud computing has become mandatory. As the standard mode of operations is no longer feasible, organisations are coping with the pandemic surprisingly well. Overall resilience to COVID-19 shocks implies supply-chain adjustment, remote work and real-time decision-making. Given the scale of disruption caused by pandemic the organisations are reacting swiftly in adapting the above-mentioned micro transformations.

Ex-post socioeconomic transformations have reminded us of the Global Financial Crisis of 2008-2009. During that time, investments were made in gold by selling off the equities. Whereas, during COVID-19 hard currencies were stockpiled by selling off gold in order to face uncertainties. In the broad socioeconomic world, the scale and pace of change is unprecedented and the national governments ought to cope with the situation.

The onset of the COVID-19 pandemic has acted like an **“accelerator”** in transforming the sociological, ecological, technological and financial ground realities into innovative new normal realities.

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Short Communication**A case study: Role of the sewage dwelling plant growth-inducing rhizospheric microbe in environmental heavy metal bioremediation with special accentuation on chromium**Chitrita Chatterjee^{1✉} and Rabindranath Bhattacharyya²¹ Department of Botany, Shibpur Dinobundhoo Institution (College), Shibpur, Howrah, West Bengal, India.² Microbiology Laboratory, Department of Life Sciences, Presidency University, Kolkata, IndiaEmail ID: chitrita87@gmail.com**Abstract:**

The chromium tolerant sewage microbes can remove soil chromium by implementing effective chromium absorption and reduction capability. As the soil microbes inhabited at anoxic to hypoxic heavy metal-containing sewage sludge, they have been adapted themselves and utilized the redox potential of chromium reduction to fulfil their own physiological needs. The sewage dwelling microbe secret different chelating compounds like siderophore, EPS (exopolysaccharides) and organic acids that help in microbial soil heavy metal absorption through cation mobility. Soil cation mobility decreases plant chromium absorption and helps in plant well-being in chromium polluted environments because of microbial chromium affinity. The soil isolated microbes eliminate environmental heavy metals and govern plant growth by secreting plant growth-promoting substances like phytohormone, Indole Acetic Acid (IAA), Indole Butyric Acid (IBA), siderophores that make iron available for plants and control soil cation mobility. Consequently, the eco-friendly, sewage dwelling microbes can be applied commercially in heavy metal contaminated crop fields because they can remove soil heavy metals through bio-accumulation, improve plant growth and, decrease the risk of biomagnification.

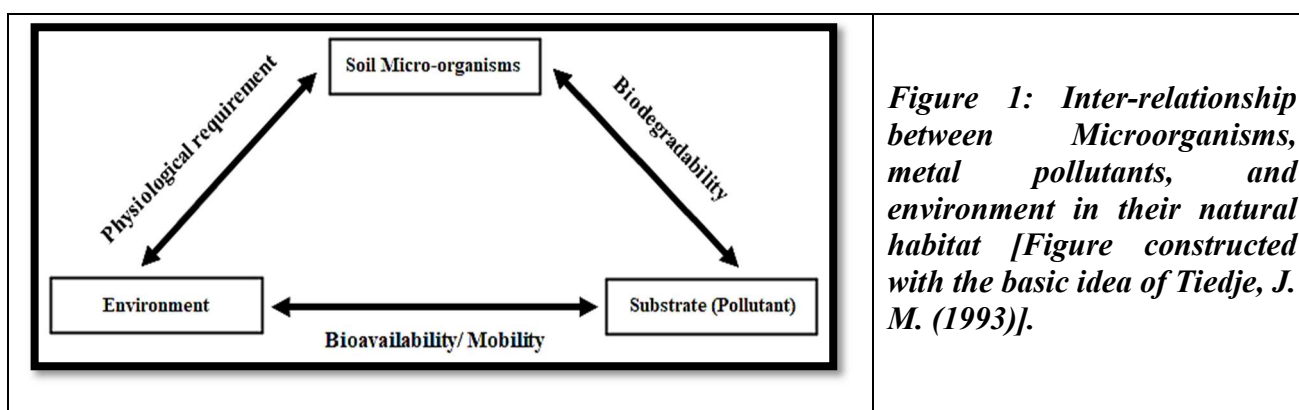
Keywords:

Chromium, Bioremediation, Reduction, PGPR, Sewage-soil, Siderophore,

Introduction:

As a result of abrupt industrialization and different human activities like unplanned cropping and chemical manure application, the deposition of various heavy metals in the environment has been increased substantially day by day. The untreated wastewater discharged from several commercial outlets for a long time possesses the capability to affect the environment adversely with heavy metals and other unsafe chemicals [Wuana and Okieimen, 2011]. In this manner, the wastewater bodies get contaminated with different heavy metals like chromium, copper, zinc, manganese, iron [Devi, 2011]. The plants that grow in heavy metal contaminated soil can absorb heavy metals from both surface-soil

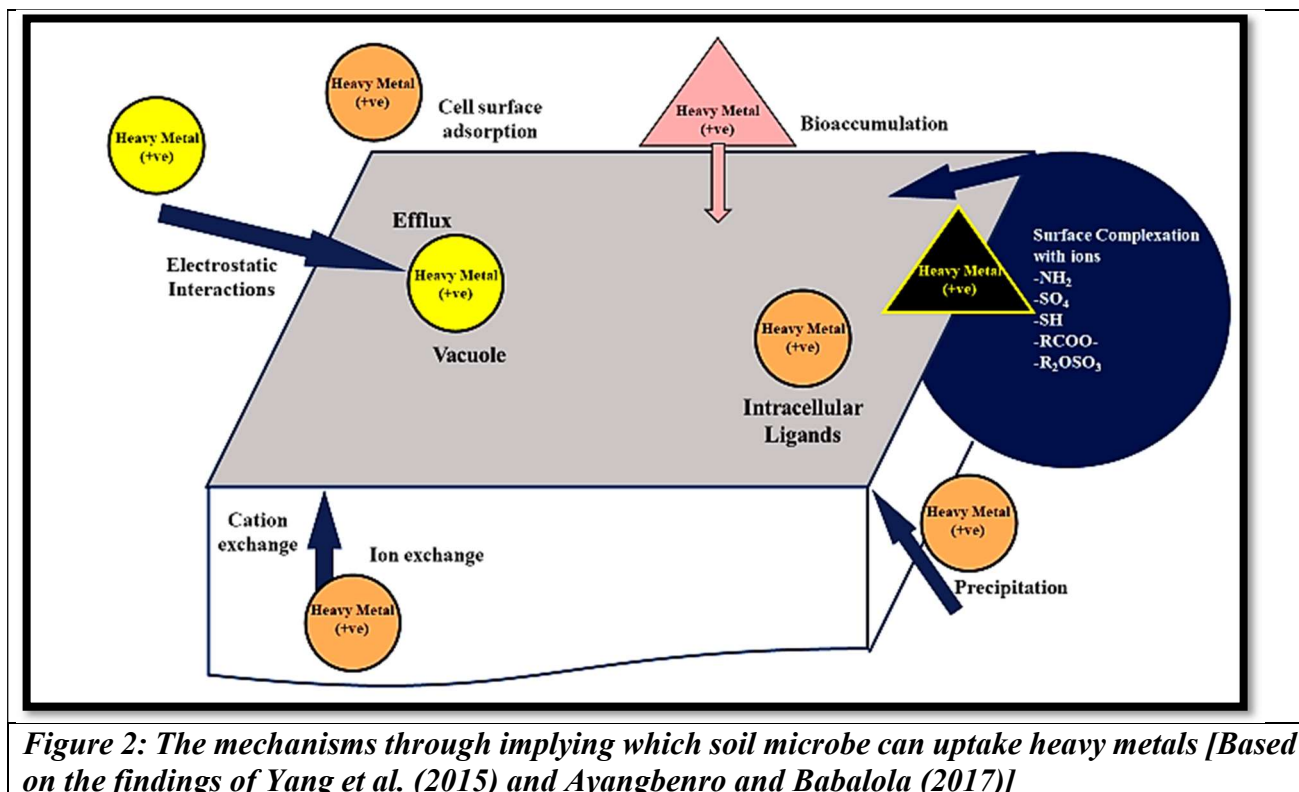
and underground soil micro-climate [Patra et al. 2004]. The absorbed heavy metals accomplished serious plant metabolic disorders by forming substances like reactive oxygen species (ROS) or cytotoxic methylglyoxal (MG) that disturbed the ionic homeostasis within plant tissue and ceased plant growth and metabolism [Hossain et al. 2012; Star et al. 2013]. The heavy metals enter the human system through skin penetration, food chain, or inhalation and cause different fatal consequences [Gadd, 2010; Kapahi and Sachdeva, 2019]. Non-biodegradable heavy metals can persist within the environment along with tissues of plants, animals, or human beings and are magnified through each trophic level. The concentration of heavy metals within dry fruit and other edible plant parts have been exceeded the values approved by the World Health Organisation (WHO) and the Food and Agriculture Organization of United States (FAO) [Naeem et al. 2009; Hussain et al. 1995]. That's why the removal of hazardous heavy metals from the environment becomes a great challenge to us. The traditional environmental metal removing methods like ion exchange technique, precipitation, electrodialysis is convenient for metal removal but time and energy-consuming, pH-dependent, non-specific, and costly [Aziz et al. 2008]. Cautious disposal and a considerable amount of metallic contaminants should be needed for conventional contaminated slur development [Gunatilake, 2015; Gray, 1999]. The cost-effective and eco-friendly alternative approach of heavy metal removal by bio-agents can be more useful to eliminate different environmental heavy metal contaminants. Microbes can be used as efficient and eco-friendly metal biodegrading agents because they have the ability to remove metallic contaminants from the environment and control plant metal absorption. Microbial metal conversion is dependent on environmental factors like pH, temperature, presence or absence of other metal ions, acids, moisture content, etc. [Gadd, 2010].



Impact of sewage dwelling microbes on environmental heavy metal removal:

Bioremediation is the in-situ eco-friendly [Verma and Kuila, 2019] approach through which microbes degrade the hazardous environmental metal contaminants or converted them to less-hazardous, bio-available organic substances. Bioremediation help in the growth and bio-mass formation of the other residual flora and fauna.

Though bacterial exposure with the metallic contaminants is required before contamination to induce the bacterial enzymatic system, a minimum amount of metallic contaminant can initiate enzymatic reaction [Adenipekun, 2012]. Heavy metals chromium, cadmium, lead, zinc, and copper can rapidly remove from the environment by bio-accumulation [Ozer and Ozer, 2003].



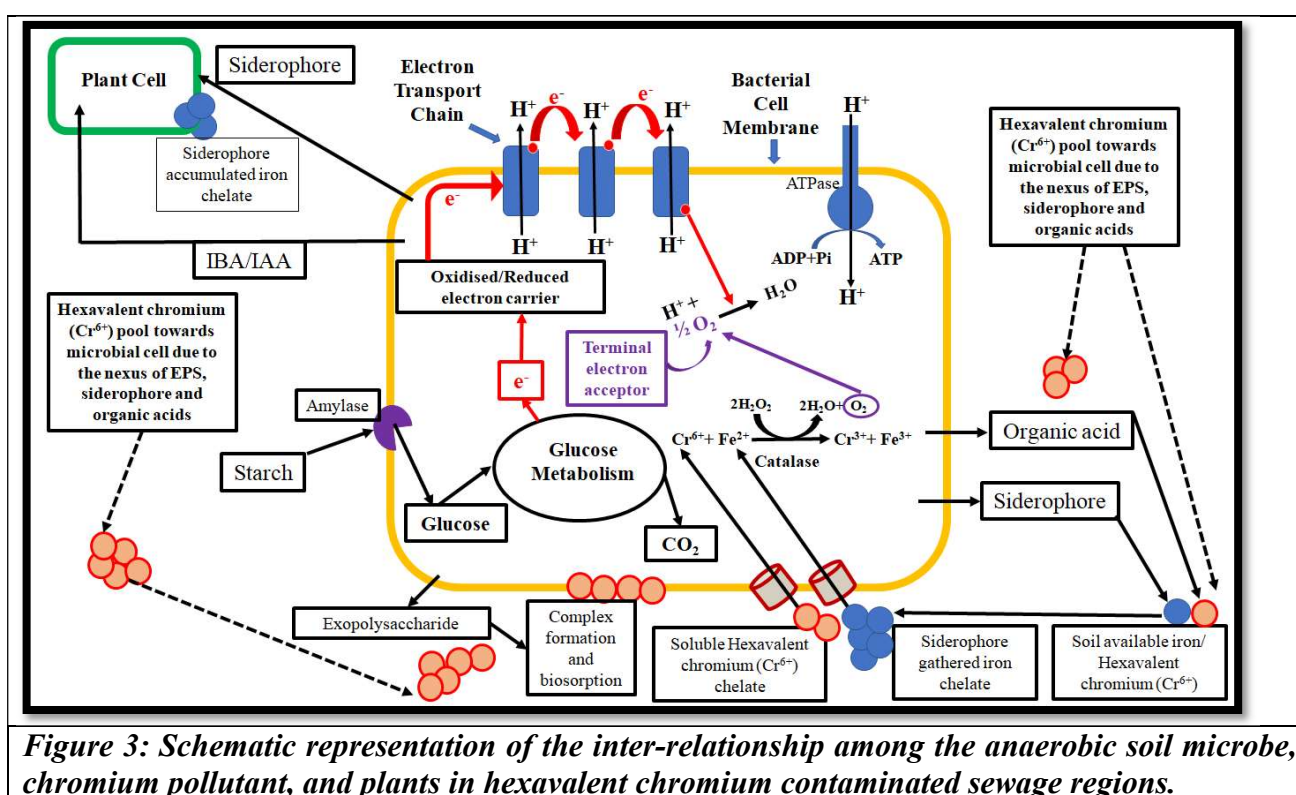
Different chemical constituents [teichoic acid (in Gram-positive bacteria), N-acetylmuramic acid (NAM), poly-N-acetylglucosamine (NAG), anionic group-containing peptidoglycan (in both Gram-positive bacteria and Gram-negative bacteria), phospholipids (in Gram-negative bacteria), lipopolysaccharide (in Gram-negative bacteria)], [Sherbet, 1978] and functional groups [carboxyl group, hydroxyl group, amine group, phosphate group] which are present on the bacterial cell wall and increased the metal-binding capability of bacteria [Doyle et al. 1980]. The amino group of microbial cell walls plays a dynamic role in chromium removal by creating Van Der Waals interaction and forming a chelate with chromium ion [Kang et al. 2007].

Kang et al. (2007) reported that the outer surface of *Pseudomonas aeruginosa* bio-absorbed hexavalent chromium and reduced it to trivalent chromium afterwards. Different metal removing microbial strains like copper and arsenic removing *Bacillus*, *Micrococcus*, *Geobacter*, cadmium, nickel, chromium, copper, lead, and zinc removing *Pseudomonas* was identified previously [Dey et al. 2016; Zouboulis et al. 2004; Lee et al. 2012; He et al. 2019; Chellaiah et al. 2018; Lopez et al. 2000; Pardo et al. 2003]. These heavy metals removing bacteria uptake environmental heavy metal through different strategies like physical adsorption by cell surface, membrane transport, ion exchange or redox reaction, bio-

absorption [Ianieva, 2009; Banerjee et al. 2018; Bernard et al. 2018] and utilize the heavy metals to fulfill their physiological needs. Heavy metals or other environmental chemical contaminants stimulate the growth of the bioremediating microbes because they provide microbial food and energy through different reciprocal metabolic pathways [Speight, 2018]. Being the transition element, chromium (atomic number 24) possesses different oxidation states such as trivalent-Cr(III), pentavalent-Cr(V), hexavalent-Cr(VI). Among which, less mobile trivalent form is abundant in the earth. The trivalent chromium generally forms a different crust with other soil minerals like calcium or silicon and remains present as ore within soil or rock. But, the second stable form, the hexavalent chromium, is not the usual component of the environment and does not take part in any biological well-being, and leaves many harmful effects on different life forms. The unusual oxidation state of chromium, hexavalent chromium [Cr(VI)], comes to nature through human activities like random industrialization. The quick and easy spreading of hexavalent chromium happened because of its high water solubility and soil mobility. The heavy metal contaminated, anaerobic waste water-dwelling microbes can fulfil their metabolic requirements by reducing the hexavalent chromium to harmless, less mobile, and non-toxic trivalent chromium [Kanmani et al. 2012]. Recently Novotnik et al. (2019) was reported the microbial reduction of the transition element manganese. They [Novotnik et al. 2019] were described that manganese tolerant microbe utilized the metal reduction potential in their cellular metabolic reaction at anoxic situations even more efficiently than fermentation. In anaerobic conditions, the microbes interact with the environmental hexavalent chromium through bio-absorption, bio-accumulation, and enzymatic redox reaction [Mishra et al. 2012]. When the hexavalent chromium remains absent, the bacteria can take part in fermentation. The chromate reductase enzyme present within the microbial cell membrane can take an important part in chromium reduction under anaerobic conditions and, the activity of this enzyme induced by co-factor NADH or glutathione [Elangovan et al. 2006] and hexavalent chromium behave as terminal electron acceptor of this pathway [Camargo et al. 2004].

While oxygen competes with chromium reduction as an electron acceptor, the presence of oxygen affects the chromium reduction pathway [Han et al. 2016]. One of the key blockades of microbial chromium reduction in neutral soil is oxygen. The oxides of both hexavalent and trivalent chromium are poorly soluble at neutral pH. Due to the insolubility, microbial cell membranes become impermeable to chromium. The hexavalent and trivalent chromium oxides are soluble in an acidic and, alkaline environment respectively. The microbes make the surrounding environment acidic by secreting extracellular siderophores and make chromium available to the microbes. Soil microbes can bind heavy metals by producing siderophores [Glick and Bashan, 1997; Braud et al. 2009a; Rajkumar et al. 2010] and low molecular weight organic acids [Rózycki and Strzelczyk, 1986; Renella et al. 2004] and make chromium available to the microbes by enhancing cation mobility. The soil microbe secreted siderophore also play a significant role in the iron extraction from organic substances and

makes it available for the microbes [Dale et al. 2004]. The solubilized iron that has entered the microbial cell enhanced the chromium reduction by performing a redox reaction. Brumovský et al. (2020) reported that sulfur-containing zero-valent iron can reduce hexavalent chromium (Cr^{6+}) and form the immobile complex oxide or hydroxide salts of trivalent chromium (Cr^{3+}) and iron. Thus, the microbe's available iron can help in chromium removal from the environment for the long term by taking part in a simultaneous redox reaction with chromium. Hydroximate siderophore is the foremost constituent that helps in the microbial chelate compound formation and ferric iron uptake through enhancing iron mobility [Powell et al. 1980; Mawji et al. 2008]. Many sulfur-reducing and fermentative bacteria have also taken part in this kind of metabolic reaction. Brumovský et al. (2020) stated the role of reduced sulfur in trivalent chromium immobilization within the microbial cells.

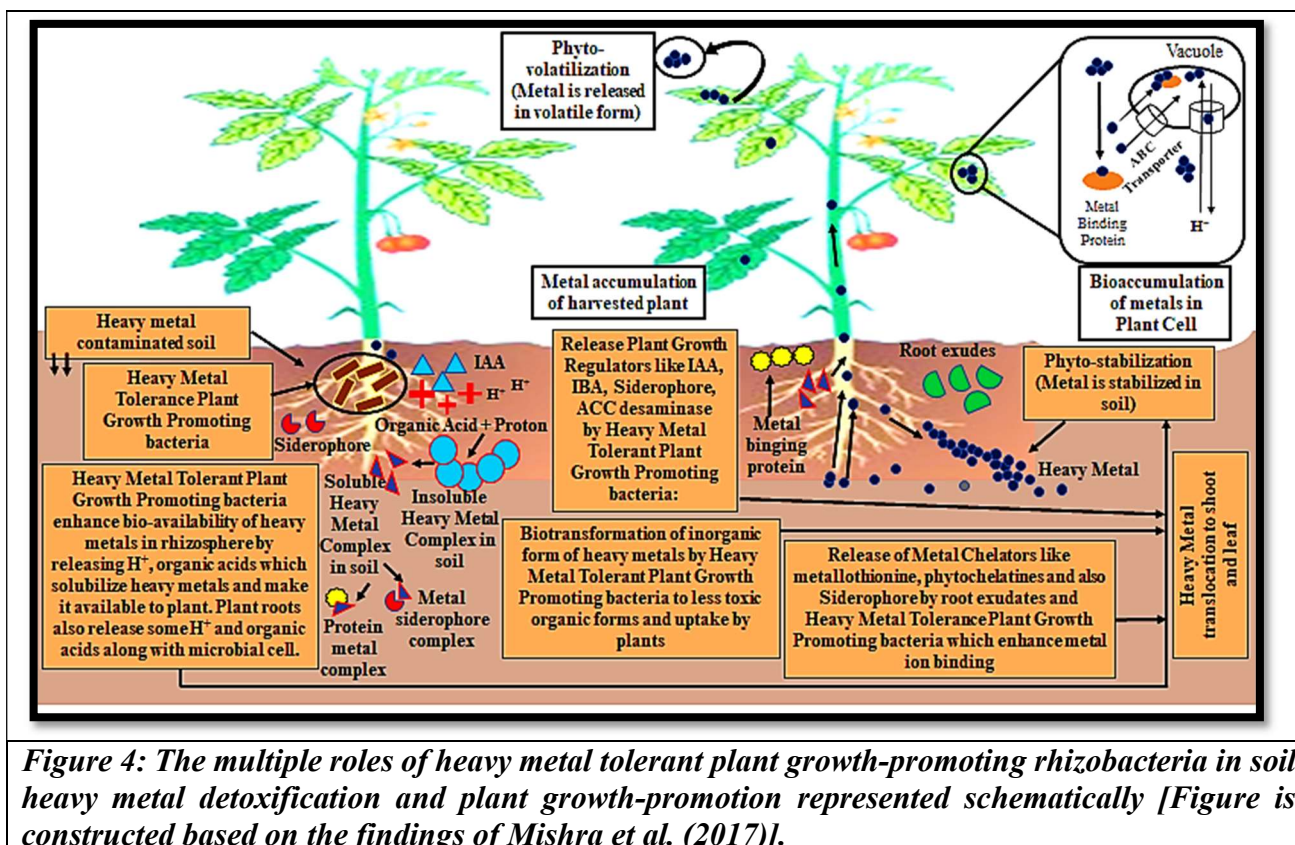


The hexavalent chromium can take part in cellular energy production by breaking down organic macro-molecules. The organic macro-molecules were come from surrounding soil within the microbial cell by different extra-cellular starch or protein degrading enzymes like amylase, gelatinase, and urease. In the anoxic to hypoxic sewage environment, the microbes can produce the required metabolic energy by reducing hexavalent chromium to trivalent chromium instead of oxygen. Alam and Ahmad (2012) was reported that the chromate reducing *Staphylococcus gallinarum* W-61, *Stenotrophomonas maltophilia* ZA-6, *Pantoea* KS-2, and *Aeromonas* KS-14 had decelerated the reduction rate in the presence of sodium azide, and sodium cyanide also depleted the chromium reduction rate whereas, uncoupling agent dinitrophenol (DNP) triggered it. The chromate reduction stimulating capability of

uncoupler dinitrophenol (DNP) suggested a strong association-ship among electron transport chain (ETC) and chromium bio-reduction. As Han et al (2016) reported that in anaerobic microbes, oxygen competes with hexavalent chromium for the electron, it could be inferred that, like oxygen, the hexavalent chromium can be attached at the terminal complex (generally complex IV) of the electron transport chain and react with the proton to form water. The significance of chromate reduction in the anaerobic conditions is that the microbial electron transport chain (ETC) can collect electrons from hexavalent chromium, which is behaved as the terminal electron acceptor in the absence of oxygen with the help of an uncoupler like DNP, the anaerobic microbes can continue the respiratory pathway. The rate of chromium reduction acceleration in the presence of DNP revealed that chromium reduction might take a significant part in the respiratory electron transport chain (ETC). The anaerobic bacteria produced energy by reducing transgenic metals like chromium [Naz et al. 2021] but, not preserve the energy gained by metallic reduction. Rather, utilize the metal reduction procedure as an electron-donating step that enhances fermentation [Novotnik et al. 2019]. Some chromium reducing *Shewanella* (Hunt et al. 2010) and *Geobacter* (Esther et al. 2015) species were also reported that conserved the energy gained through chromium reduction for further cellular metabolic purposes.

Microbial impact on plant metal accumulation and plant well-being:

The entrance of heavy metal within the food chain depends on the composition of flora and fauna of regional micro-climate because the plant-alliance soil microbes play an important role in soil metal mobility, plant metal uptake, and biogeochemical cycling of soil heavy metal. Chromium also competed with other elements like phosphorus, sulfur, or iron [Shanker, 2005] for the plant or microbial cells and finally entered by forming chelate compounds or through active transport. The presence of hexavalent chromium may also increase the plant's soil mineral consumption [Wyszkowski and Radziemska, 2009] which is not good for plant health. Many soil microbes, including *Bacillus*, compete for nutrient minerals like sulfur, phosphorus, chromium with plants. Different *Bacillus* species played a significant role in soil mineral mobility, mineral absorption and accumulation in their vicinity [Wani and Khan 2010]. The soil microbe-mediated plant metal absorption reduction has a good impact on human and plant health because it lowers the chances of heavy metal bio-magnification. The Bio-concentration Factor (BCF) value, which is the ratio of the metal concentration in the vegetation to the concentration in the soil supporting that vegetation, indicates whether the heavy metal bio-magnification occurred through the vegetation or not. A lesser than one BCF value in plants indicates that they probably only absorb but do not accumulate heavy metals within the cell [Glick and Bashan, 1997]. Gupta et al. (2012) was evaluated the role of sewage microbe in decreasing bio-magnification by calculating BCF.



Some heavy metal resisting soil rhizospheric microbes play a potent role in the survival and growth of the metal-sensitive plant by alleviating the effect of heavy metal and providing nutrients to the plants [Benizri and Kidd 2018]. The plant growth-promoting rhizospheric bacteria (PGPR) promote plant growth by fabricating extracellular plant growth stimulating substances like Indole Acetic Acid (IAA), Indole Butyric Acid (IBA), siderophore, phosphate degrading enzymes in the root-adjacent soil. Different Heavy metal stresses tolerating, plant growth-promoting rhizobacteria like (PGPR) *Bacillus*, *Streptomyces*, *Pseudomonas*, *Methylobacterium* strain have been reported for their potent role in the plant growth improvement in the presence of heavy metal [Sessitsch et al. 2013]. The rhizospheric soil-borne microbes play a significant role in plant cell division and elongation by secreting Indole compounds in low concentrations [Susilowati et al. 2002; Spaepen et al. 2007]. The metal-resistant sewage bacteria produce siderophore and phytohormones to help the survival of the plants in heavy metal contaminated soil. Siderophore protects the plant from the deleterious effects of soil heavy metals and also provides growth stimulators like iron to plant [Rajkumar et al. 2010]. Some stress-tolerant Gram-positive and Gram-negative microbe also form a biofilm with different exopolysaccharides (EPS) that convert the toxic heavy metal to the non-toxic form and protect the microbe and surrounding plants [Whitfield et al. 2015; Gupta and Diwan, 2017].

In this way, soil microbes protect plants in stressful environments by lowering the absorption of high-risk heavy metals and producing different growth inducers. This type of complex ecological

relationship and its interaction with environmental abiotic factors should play a key role when implemented in environmental management.

Concluding remarks:

In several ways, the plant and its rhizospheric bacteria help each other and maintained a symbiotic association. Many of the bacterial genes have been co-evolved with plant in a conserved and stable manner and has considered as selection unit [Rosenberg and Zilber-Rosenberg, 2016]. Because of the dependence of the plant with their rhizospheric microbe, recently different long-term and short-term plant-microbial volt have been created which have tried to help out the plant to grow in consortia with their rhizospheric microbes and form microbiome just as in their natural habitat [Gopal and Gupta, 2019].

In the future, more investigation has to be required to check the expression of genes responsible for conducting the respiratory electron transport chain (ETC), chromium reduction pathway, and plant chromium accumulation. The cross-talk mechanisms of these genes might possess a considerable impact on human well-being and crop development.

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