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# Design of Green and Sustainable Industrial Park

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**Abstract:** A green and sustainable industrial park is an area specially allotted for industries with initiatives to reduce waste, pollution, share resources (such as information, materials, water, energy, infrastructure, and natural resources), and help achieve sustainable development, with the intention of improving environmental quality. Our study aims at a design process with a flexible and adaptable layout of the park to maximize use of renewable energy and minimize carbon emissions. The work includes impact studies, waste treatment, sustainable processes like carbon capturing, renewable energy sources, eco-friendly construction materials, rain water harvesting, permeable pavements etc. Here we transform a normal area of land into an efficient and eco-friendly industrial zone. The study can be considered as a general design as the technologies adopted here can be applied irrespective of locality.

**Keywords:** Green Technology, Sustainable engineering, Low carbon emission, Sustainable development, Industrial Park

## I. INTRODUCTION

An industrial park can be defined as “a large area of land, divided and developed for the use of different firms simultaneously” by sharing resources and common amenities. Various aspects of eco-industrial parks (EIPs) have been widely studied over the past decades. The main objectives of Green Industrial Park include reducing pollution and waste, sharing resources efficiently and minimizing the impacts on the environment. The basic principle for Green and Sustainable Industrial Park is that the total benefit (improvements to social, economic and environmental impacts) achieved by working cooperatively is higher than working as an individual facility. Green Industrial Parks make the ideal environment for efficiently applying the idea of industrial symbiosis, where a number of industries are clustered in one place to benefit from waste as an input to production. In this assembly, anchor industries appear as well as scavenger industries which ensure that the loop is closed as they function on the by-products of those anchor industries. Here, we introduce the design of a Green and Sustainable Industrial Park, to produce a flexible and adaptable design for an industrial estate to maximize the use of renewable energy, eco-friendly materials from waste products, and to minimize carbon emissions.

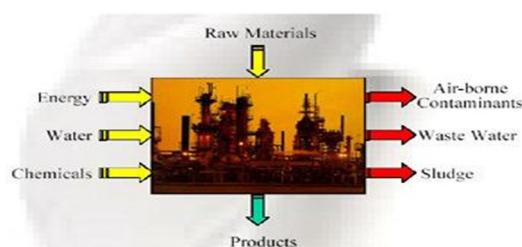


Fig.1. Industrial inputs and outputs

## II. ENVIRONMENTAL IMPACTS

Industrialization is important for the economic growth and development of a society. But its various processes can be harmful to the environment. Thus, the very first procedure of designing an Industrial Park is to find how it affects the environment. The Impact study or an Environmental Impact Assessment can be done by checking various parameters. The purpose of preparing EIA is to ensure the decision makers to consider the environmental impacts when deciding whether or not to proceed with a project.

The parameters include Air, Water, Noise, Seismicity, Negative and Positive impacts on the environment etc. The studies include environmental baseline data like location and physiography of the place where the park is planned. Studies on air quality, Water quality, Socio economic studies, what are the changes in land pattern and various environmental characteristics etc. Environmental monitoring plans and environmental management plans should also be considered. Most of the environmental issues due to the development of an industrial park includes the change in land use pattern, non-renewable resource usage, air pollution, water pollution, soil pollution etc. Thus, while considering sustainable and green development, the main concern should always be to reduce the above-mentioned factors. The methods for this will be discussed further in detail.

### III. WATER SUSTAINABILITY

#### A. Wastewater Treatment

Waste treatment are the activities required to ensure that waste has the least harmful impact on the environment. The adopted methodology for this includes a tertiary treatment process. Generally, the goal of wastewater treatment is to transform the raw sewage into water clean enough to be discharged into a water body without causing harmful environmental or ecological consequences. Sewage treatment includes the combination of physical, chemical, and biological processes to achieve goals such as: 1) to reduce “aesthetic pollution” - smelly organic matter, 2) to kill the pathogenic microorganisms and to remove the toxic wastes, 3) to reduce the organic material or B.O.D., and 4) to remove inorganic nutrients like nitrogen and phosphorus that can cause eutrophication. Sewage treatment plants are not only designed to purify drinking water, but also to reduce the potential of sewage to pollute aquatic ecosystems.

An Effluent Treatment plant can be constructed to treat the effluents from various industries. It includes; (1) First the effluent passed to the screening chamber and then to the grit chamber to remove larger particles if any, (2) Then send to equalization tank – this is done to equalize the flow of water, (3) Flash mixing is then used to mix chemicals to water and mix thoroughly to attract particles and clump them and then flocs are allowed to form in the flocculator, (4) Primary clarifier is the place where the solid particles created from the above process is allowed to settle in the primary clarifier, (5) Aeration tank - the microbial growth in the water is increased by pumping oxygen into it, (6) Secondary Clarifier removes the activated sludge, (7) After these processes, Flash mixing and flocculation is done again (8) Tertiary clarifier is where the final cleaning process is carried out to improve the quality of water, (9) Sand filter and activated carbon filter are used to purify water, (10) the next step includes Chlorine disinfection (11) Clean water is then discharged to the well or tank for reuse, (12) Sludge collected is then allowed to dry in a sludge drying bed and later it can be transported to the sludge disposal area.

This water treatment method makes the Industrial Park sustainable with water. The process can recycle about 87% of waste water to pure water. This makes the park sustainable for water. Though the method is a bit costly, it is the most efficient method for effluent treatment.



Fig.2. An Effluent Treatment Plant

#### B. Rainwater Harvesting and Rain Gardens

Rain water is the purest form of water that is available to us. Collecting the rainwater is a good practice for achieving water sustainability. Rain water harvesting is considered as the best and cheapest alternative to the traditional water supply systems. It is basically the process of rainwater collection from the surfaces on which rain falls, filtering it and storing it for multiple uses. Various methods can be adopted for harvesting rainwater. Some techniques like rainwater barrels, dry and wet systems, green roof etc can be adopted. Rooftop rainwater harvesting is the most common method. Water from rain is collected from roof through pipes and is stored in tanks or sumps. It is a method that is not much expensive. Industrial rain water harvesting leads to the reduction in water consumption, quick and easy installation, and also a complete solution to stormwater.

Rain gardens are specially designed garden beds that could filter stormwater run-off from drains or from the surroundings. They are also known as bioretention systems, as they use soil, plants and microbes to biologically treat the storm water. Though they look similar to the normal garden, they are designed to stop the stormwater runoff from polluting the other waterways with nutrients, rubbish and sediments. This system uses a special soil type, such as loamy sand, as a filter media that drains quickly and does not release nutrients into the storm water. In a rain garden we adopt special plants with roots that keep the filter media absorbent and break down the pollution. Mainly plants like, Summersweet, Red osier dogwood, Blue flag iris, Meadow anemone etc, that can grow in sandy soils and can tolerate dry conditions for several weeks in between rains are preferred.



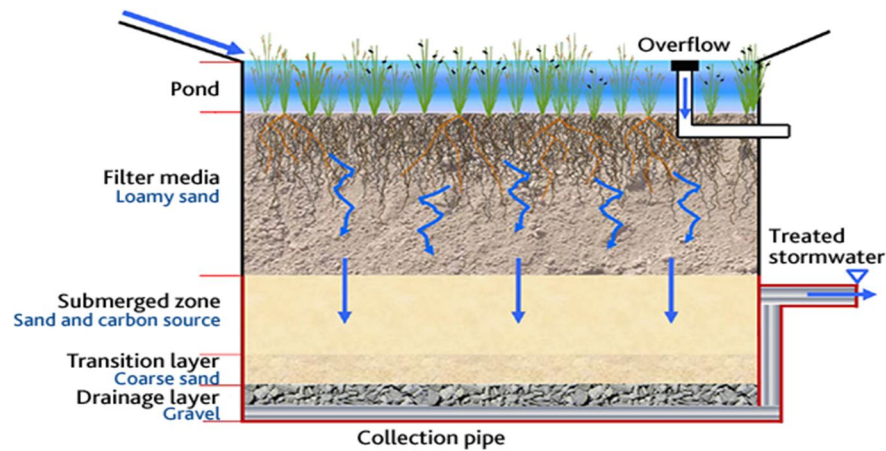


Fig.3. Working diagram of a rain garden

### C. Permeable Pavements

Permeable pavement enables the infiltration of stormwater run-off. It typically includes permeable asphalt concrete for its construction. The goal of this system is to generally control the stormwater at its source, reduce run-off, and to improve the water quality by filtering pollutants from stormwater. This material enables the stormwater to flow through it and it could be stored in an underlying stone reservoir. Thus, it increases the groundwater infiltration and recharge. Permeable pavement provides a wide variety of positive results like; local flood control, reducing soil erosion and groundwater pollution and also provides a greenspace (i.e., grass ground cover, shade from tree canopies etc). Permeable pavements are commonly used on roads, paths, parking lots etc. These paving systems are as strong and durable as traditional paving materials. These pavements can also be made from environment-friendly recycled materials, which reduces the amount of waste in the system and at the end of their lifespan, they can be easily recycled, further reducing their carbon footprint. On the whole, permeable pavements are themselves considered as sustainable.



Fig.4. Permeable pavement

## IV. CLEAN AIR

In the world, there are thousands of industries that create a negative environmental impact. Factories and industries keep on expanding everywhere, and this deteriorates the quality of the air that people breathe. We can also find them throw their long chimneys erected high into the air, with non-stop smokes and fumes coming out of them. This is why factories and industries are considered as main sources of air pollution. Industrial pollution is considered as the primary source of environmental contamination. This human-made source has a hazardous effect on the health of living organisms and on the entire planet. To reduce these effects on the environment the main thing that can be done in industries is carbon capturing. Carbon is the major content of pollutant present in the effluents from industries. Carbon capturing is a method in which the carbon content in smoke or effluents from industries is captured before exhausting to the atmosphere.

The process of carbon capturing is of three types, Pre combustion, Post combustion and oxy fuel. The most adaptable method in industries is Post combustion. Post combustion capturing is the capturing of carbon from smoke after the burning. In this method, Carbon dioxide is separated from the flue gas from industries by bubbling the gas through an absorber chamber which is packed with some liquid solvents (such as ammonia). Once the chemicals in the absorber chamber become saturated, a stream of superheated steam at around 120 C is passed through it. This releases the trapped Carbon dioxide, which is then transported to proper disposal areas.

This method reduces the air pollution to an extent as carbon is one of the main pollutants of the air. Removing carbon from the effluent can reduce greenhouse effect, global warming, ozone depletion etc.



Fig.5. Smoke-stag (air pollution)

## V. ENERGY SUSTAINABILITY

Sustainable energy is a form of energy, that meets our today's need for energy without depleting them and can be used over again. Sustainability for energy can be obtained by using renewable energy sources like wind energy, solar energy etc. Sustainable energy should be widely encouraged as it does not harm the environment and is available widely free of cost. The main aim of energy sustainability is using green energy so that the impact on the environment is decreased and moreover if energy is generated in the park itself it can reduce the cost for electricity.

### A. Solar Energy

Sun is the energy source of the earth. Solar Energy is the most easily available energy. Solar Energy is adaptive to any type of plots. It is the cleanest form of energy and no other transformation of energy is required. Evidence of intensive use of this alternative form of energy source can be seen throughout the globe. Solar energy is trapped using solar panels and stored for use. The solar panels are available in various sizes. The size can be selected in a manner that maximum power can be generated from minimum number of panels. Solar Panels can be provided in the rooftops of buildings. The parking areas can be completely made of solar roofs. The best example for a solar parking area is Cochin International Airport. The excess energy generated can be sent to the grid and it can be retaken whenever needed. The initial investment will be a bit costly but compared to future electricity bill the method will be profitable.

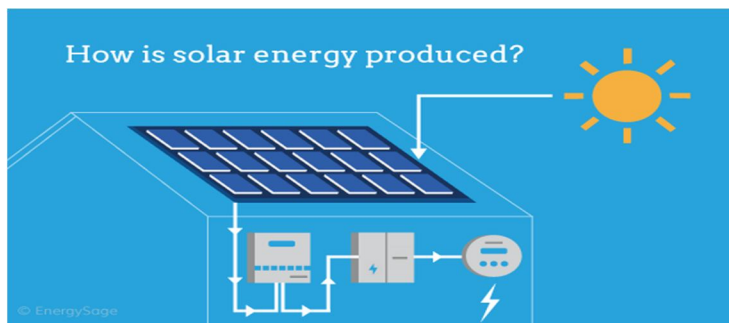


Fig.6. Solar energy production

**B. Wind Energy**

Wind Energy is another clean and renewable source of energy that can be fetched from nature, as it doesn't pollute the air like power plants which rely on chemicals causing human health problems and economic damages. If the site is an area which is prone to continuous wind speed of 9mph wind turbines are a source of power generation. In near future, sustainable energy like wind power will become a large industry and fossil fuels will no longer be used again. Wind turbines can be placed at suitable places at suitable heights to fetch energy. In Kerala this method is not so suitable as wind speed is not up to the required value.



Fig.7. Wind mill (wind energy production)

**VI. GREEN MATERIALS**

Based on the studies the best method to go green is using green materials for construction. It is a concept which considers the social and environmental impacts of development and thereby introducing renewable or abundantly available resources for the construction processes that are environment-friendly. Green materials are the one which reduces the carbon footprint. The buildings can be built using recycled materials or materials that are produced from waste products or by-products. GFRG sheets manufactured by FRBL, Kochi Kerala are the best example for recycled building material. The core material of GFRG is phosphogypsum. The raw gypsum is a by-product of FACT acid plant and hence it is a green material. The material is reinforced with glass fibre to provide load bearing capacity. The material is cheap and affordable for construction.

TABLE I: Comparison bw GFRG Panel and Normal brick wall

Characteristics	GFRG Panel	Normal Brick Wall
Construction Technique	Dry Construction	Wet Construction
Speed of construction	Faster	Slower
Manpower Saving	Less labour usage (Savings of 20% to 30%)	Labour Intensive
Acoustic	Offer cavity insulation	Limitations in sound insulation
Fire performance	Fire resistance up to 4 hours	Depends on construction type
Seismic protection	Ideal for earthquake prone zones	Heavy weight and may lead to failure
Refurbishment	Can easily be dismantled or altered	Consumes lot of time
Green	Green and recyclable	Ecological Imbalance



Fig.8. GFRG Panel

## VII. CONCLUSION

Sustainable development is the development that meets the needs of the present without compromising the needs of the future. Sustainable development mainly aims at people and their well-being, in a context where the nature-society imbalances can threaten economic and social stability. From the above-mentioned methodologies, we came to the conclusion that development of an industry is possible without harming the environment. It not only saves the environment, but also saves the national budget, time and also helps in the coordination between the natural resources and people, and conserves natural resources for the future.

In this study, we came across various methods like wastewater treatments, rainwater harvesting and rain gardens, and permeable pavements that could help in recycling and conserving the water resources without polluting the available sources. Availability of clean and fresh air is the basic requirement of every living being on the planet. Developers should take at-most care while expelling their smoke residues out of their smoke-stacks. Proper screening must be provided to the expelling smoke so that it is deprived of the chemicals and doesn't harm the environment. Usage of renewable resources like wind and solar energy is a giant leap towards the goal of sustainability. This shows the concern of humanity towards the delicate non-renewable resources. Usage of green materials for construction helps in energy conservation, reduced maintenance, lower costs and greater design flexibility. More than that, it saves the environment from harmful effects of other construction practices. To illustrate, studies have proved that 16% of all the fossil fuels are consumed every year in order to turn those raw materials into construction products. By considering all these facts, we conclude that it is high time for mankind to shift to a new methodology that could create structures using processes that are environmentally responsible and resource-efficient throughout its life-cycle from designing, construction, operation, maintenance, renovation and reconstruction. I.e., We should achieve sustainable development without harming our surroundings.

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