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Microbes: Transformers of the Future World

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Abstract: Microbes are one of the most important organisms found on the Earth. They serve as both beneficial as well as harmful to both plants and animals. They are known to cause a large number of diseases and infections in plants as well as in animals both and even in certain case their presence causes benefits to the organisms on which it is surviving. However, it is not known that these microorganisms are slowly and slowly transforming our future world and it is interesting to know that they are doing so from much ancient times. This review will throw the light on the role of microbes in transforming the future world.

Key words: Microbes · Future world · Transformers

INTRODUCTION

Microbes are ubiquitous in nature. They are found in every part of biosphere *i.e*., air, water and soil. Their existence in the world was only confirmed after the discovery by Leuwenhoek who first discovered "protozoa" although they existed since Earth first sustains life. In fact, life existence was found in water in form of colonies of microbes named "microbe mat". They perform number of functions, however, their primarily role is seen in regulation of biogeochemical cycles. They even serve an essential part for cleaning up the environment as they act as decomposers. They are have the ability to survive and flourish under extreme of conditions *for e.g*., some of the microbes are found inside rocks, while some can even in vacuum of outer space [1,2]. Several other functions of it have been evolved from ancient to present condition like their use as ingredient for preparation as well as preservation of some foods and beverages. Recently they have been revealed in having a hand in precipitation and weather. Apart from its many beneficial uses, it also causes harmful effects on plant and human health by causing number of diseases.

Role of Microbes in Transformation of Future World: From past many years microbes are used for various useful purposes. They have played a role in transforming the world from ancient times *for e.*g., the production of vinegar through the water percolation by woods shavings was extensively been used and practiced. Similarly, the fermentation of yeast into beer, production of yogurt by *Lactobacillus acidophillus*, production of several cheeses and production of sauerkraut from cabbage fermentation are some of the commonly known useful uses of microbes. Their existence was confirmed only after being discovery of microbes by Leuwenhoek. The discovery of antibiotics on one hand revolutionized medicinal field, while on the other hand, it became one of the reason for the transformation of world from past to present. Besides this, in agricultural field, microbes had also showed several uses like certain bacteria have the capability to make plant resistant against diseases [3].

Microbes had an important hand in revolutionizing the world from past to present and later in to future. Several microbes are being discovered and identified for their role in one or the other way. It is interesting to know that there are some of the microbes that had evolved or their roles have been identified that are giving way for new world. Following are some of the microbes that play a role in transformation of future world:

Bacteria Consuming Pollutants and Generating Electricity: Pollutants, major reason of polluting environment, are an important problem from past many years and are being increased day by day. Several measures are being taken up for its complete eradication yet not much success is being achieved. However, it is interesting to know that there are large numbers of microbes that helps in cleaning environment by consumption of pollutants. In fact, there are certain

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bacteria that will help in transforming the world as they serve the dual purpose *viz*., pollutants consumption and electricity generation. These bacteria not only solve the problem of pollutants but also cope up with the emerging problems of electricity generation to some extent. Biologists at University of Southern California had found out that there are many bacteria that solely depend on electricity as they feed and excrete just the electrons. While some of these have the capability of forming nano-wires or bio-cables [4]. Following are the bacteria's that serves the dual functions *i.e*. electricity generation as well as consumption of pollutants:

Shewanella (genus Shewanella), a deep-sea bacteria, is a bacteria with tiny wire-like oxygen seeker appendages which are known as nanowires. The latter develop when this bacteria is kept in low oxygen environments. These nanowires besides digesting toxic wastes (including PCBs; polychlorinated biphenyls and chemical solvents) also produce electricity. It has been observed that when these nanowires are attached to platinum electrodes, there is flow of current through them [5].

Another group of bacterium, belonging to the genus *Desulfitobacterium* have capability of breaking down and detoxifying some pollutants [6,7]. Until now these bacteria were not known to produce electricity. But as these bacteria perform large number of metabolic activities these may convert large number of food sources into electricity [8]. One such bacteria, *D. halfniense* was discovered that fed on chlorinated compounds and solvents and devoured them and ultimately cleaned these pollutants [9]. Evidences have shown that it could dechlorinate PCBs. A strain of *D. hafniense,* DCB2 generated electricity in certain microbial fuel cells (MFCs). The latter was possible when humic acid or a humate analogue, *viz.*, anthraquinone-2,6-disulfonate (AQDS) is added as mediator of electron carrier. It has been observed that when format was utilized as fuel, gram positive bacteria (spore forming) generated electricity up to 400mW/m^2 of cathode surface in a single chamber of MFC with platinum as air-fed cathode. However its mechanism is still not clear and experiments are being conducted to understand this phenomenon by using toxic wastes like pesticides and chemicals [6]. Out of the several strains of this bacterium only the strain (DCB2) generated electricity for over 24 hours (Energy Tech, 2005) in MFCs [10].

Besides, another group of uranium mobilizing bacteria, *Geobacter* also helps cleaning up pollutants. Outer surface of these bacteria possess conductive pili or nanowires which generate electricity. The nanowires also help the bacteria to survive under such toxic environment vis-α-vis impart protection to them. Another such bacterium, *D. acetoxidans*, uses iron as terminal electron acceptor, transforms organic matter into electrical energy sufficient enough to light up a bulb or run a simple computer [10]. *G. sulfurreducens,* another bacterium of this group, transmits electrons to larger distance using their nanowires [11].

The *Cyanobacteria* (Blue green bacteria) also convert sunlight directly into electricity may be used for electricity production. Besides, these bacteria, through the process of photosynthesis, fix 25 giga tons of carbon from the atmospheric CO_2 amounting to 20-30% of total photosynthetic productivity occurring on Earth. The high energy electrons produced are consumed for its own survival needs as well as for generation of electricity. A photosynthetic microbial fuel cell (PMFC) having growth chamber and electron harvester, has been developed to produce these electrons. In these cells, bacteria grow in contact with anode. When exposed to sunlight, they generate electricity in the PFMC [12].

In 2010, Lars Peter Nielson observed that at the bay at Danish port of Aaerhus, bacteria of another family, *Desulfobulbaceae* generate electricity. Due to nearly 92% similar of the genes, these bacteria were placed in this family. Although these bacteria are found only in mud having deficiency of oxygen but the locale of their presence is not at all deficient in oxygen. Together, these bacteria transfer electrons from the deeper surface to the upper surface. These transferred electrons are obtained from the food and get transferred from one protein to another and finally deposits on oxygen thereby giving out energy for their survival [11].

Bacteria That Turns Newspapers into Bioethanol: A new microbe, TU-103 was recently discovered at the Tulan University which can produced bioethanol (more energy dense than ethanol) using cellulose of the newspapers as feed [13]. This discovery has paved way for production of bioethanol with a cheap production rate and would obviously be helping in lowering the increasing value of biofuel.

Bacteria Found in Panda Poop Used for Production in Biofuel: Not only the above bacteria helps in production of biofuel, there are nearly 40 microbes found in Panda poop that break down lignocelluloses-a tough plant material found in grasses, corn stalks and wood chips [14] and generate biofuel from plant waste. These lignocelluloses are broken down into simple sugars by these microbes which can be easily fermented

into bioethanol. Studies at the university of Wisconsin-Madison, revealed that certain bacteria can transform these sugars into oils and fats which may be used as biodiesel [15].

Bacteria Converting Human Waste into Rocket Fuel: An anaerobic bacteria, *Brocardia anammoxidans* (family Planctomycetaceae) converts human sewage into hydrazine- used as a rocket fuel. The hydrazine so produced is stored in specialized organelle, known as anammaxosome which is analogous to mitochondria [16]. The latter is surrounded by a highly compact ladder-like lipid membrane; and it binds hydrazine [17]. This bacteria converts nitrite and ammonia, present in human waste, directly into nitrogen gas.

Bacteria That Reduces Acid Run-off in Mills: Mining operations causes huge impact on environment by increasing the carbon dioxide amount in the atmosphere. This increase will not only contribute to change in global climate but also to the human health. In mining operations, in mine tailings sulphur reacts with water and oxygen to produce sulphuric acid, a highly toxic material for the environment contributing to climatic change, to a larger extent. Higher amount of this run-off affects the environment more adversely as it dissolves carbonates found in the rocks and contributes to elevated levels of carbon dioxide in the environment. It is interesting to know that at McMaster University, two bacteria (*Acidthiobacillus feroxidans* and *Acidiphillum spp.*) have been isolated from mine tailings pond in Ontario which use elemental sulphur as its energy source and reduce the toxic runoff vis-a-vis its affect on the climate. *Acidithiobacillus ferroxidans* was found on outside while *Acidiphillum* on inside of mine tailings.

Raw sulphur was utilized by *A. ferroxidans* (located outside) to produce different chemical forms of S which were later consumed by the *Acidiophillium.* The S compounds produced by the latter were again used up by *A. ferroxidans.* This cycling, hence, will reduce the production of sulphuric acid during acid mine drainage and generate 40-90 % less carbon dioxide for release in to the atmosphere [18].

Soil-Dwelling Bacteria That Kills Cancerous Cells: Cancer is one of the dangerous diseases and not much cure has been yet found out. Professor Neil Minton of the University of Nottingham has observed that *Clostridium,* a soil dwelling bacteria, spores of which when injected in the tumor (an oxygen deficient area) of a cancer patient along with the anti-cancerous drug, secretes a specific bacterial enzyme which activates the anti-cancerous drug [19,20].

Bacteria That Consumes Oil Spill Gases: Certain bacteria help bioaugmentation, a process that cleans up oil spills in oceans and rivers. A gram positive bacteria, *Alcanovirax borkumensis* increases in number during oil spills [5], in upper layers of fresh as well as marine waters like Mediterranean Sea, Pacific Ocean, Arctic Sea and Gulf of Mexico. This bacterium makes its appearance after the oil spill and approaches about 80-90% of the microbial community. To degrade oil in the spill, these bacteria undergo an aerobic reaction [21,22]. On approaching an oil droplet, they excrete glycolipids for covering oil molecule and it reduces in surface tension between oil and water for effective degradation of the oil droplets of the oil spill. Bacteria also accumulate around the oil droplet and make a bio-film which also helps in breakdown of oil [23]. The oil molecule (hydrocarbons) is broken down to fatty acids or carboxylic acids which are utilized in the TCA cycle of the bacteria. In deeper layers of seas and oceans, the level of oxygen is much lower and this process may take several months to years to break down oil spill. The process is associated with certain disadvantages as they deplete the oxygen level and increase the level of carbon dioxide [21,22].

Bacteria That Breaks down Plastic Bags: In the modern age, we use plastic in multifarious activities and after use, the disposal of waste plastic is a big pollution threat. A Canadian student in 2008 found out that there are certain bacteria which degrade plastics. Some other studies at the University of Dublin reported bacterial degradation of plastic bottles but the impacts of this on the environment are not assessed [5]. Analysis of the gut of moths larvae of *Ploida interpunctella* (wax worms) indicated that certain bacteria residing there in utilize plastic as energy source [24]. Plastic feeding bacteria were also found in Sargasso Sea (North Atlantic) [25].

Thus, the above description indicates that these microbes have paved a new way to a cleaner world by overcoming the problems of pollution *viz*., pollutants and gases of oil spills by converting them into usable products; degradation of plastic. Their role had not finished here; however, there are other bacteria that contribute their role in many other aspects like, the degradation of newspapers, human waste and panda poop into bioethanol, hydrazine and biofuel respectively. Besides these, microbes have even showed new light in

the treatment of cancer patients. Hence, microbes contribute an essential role in changing future and may be called as “Transformers of the future world”.

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