

## Soil Microbe-Mineral Interaction Concepts: Hypotheses to Theory

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### Abstract

The concepts related to microbe-mineral interactions in soil are generalized as controlling actions for mutual interests of both the microbes and the plants as if it all were a buffet where nutrients are offered (Lopez-Guerrero's hypothesis). An attempt is made, in this paper, to theorize such hypotheses by arranging their common points and in this way submitting one more hypothesis: microbes play their roles in fauna as they do in flora. Further it is discussed whether a so called pathogen is immune system strengthener for existence of biosphere in environment.

**Key Words:** Bioremediation; Commensalism; Evolution; Immune system; Inoculation; Micro-continents; Microbe-Mineral Interaction; Niche differentiation; Pathogen; Plant Nutrition; Rhizosphere; Root Exudates; Vaccination

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### Introduction

The Plants receive nitrogen, phosphorus, sulfur, etc nutrients of inorganic nature from manure or fertile soil through particular microbial associations at root level leading to enhancement in nutritional resource availability. The current researches reveal that root associated microbes tend to increase the bioavailability of soil-borne nutrients and contribute to plant mineral nutrition enhancement (van der Heijden, *et al.* 2008). The feebly bio-available organic forms of nitrogen, phosphorus and sulfur are metabolically depolymerized and mineralized to effective bio-available forms by some specific microbes, bacteria and fungi, whose growth is obviously essential for health and wellness of flora. The microbes receive root exudates, a line of complex organic molecules like flavonoids and strigolactones and terpenoids, for their existence from plants which are dependent on root associated microbes for uptake of inorganic nutrients. Some of the studies on microbial variations in different plant species and accessions have been conceptualized by Hartmann, *et al.* as a hypothesis which states that plant root exudates are crucial in shaping plant-microbe interaction (Hartmann, *et al.* 2009). The composition of soil bacteria and that of rhizosphere (root-soil interface; 1 to 7 mm of soil from the root surface – Hiltner's submission) and endophytosphere (inside root portion) too differ, as the sequential analyses reveal. On this basis Bulgarelli, *et al.* hypothesize that plants select for specific bacterial taxa and exert a kind of control over their microbial (Bulgarelli, *et al.* 2013). Furthermore considering the comparative genetic approaches like GWAS (genome-wide association study) Jacoby, *et al.* perhaps reasonably infer that plant genes and processes are

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important for controlling how plants shape the rhizospheric microbiome (Jacoby, *et al.* 2017). Still, the interesting phenomena regarding shaping of rhizospheric microbes appear to have some concerns with interactions of microbes with both the exudates and the minerals.

As far as phenomenon of inorganic contents uptake part of plant nutrition is concerned, microbial interactions with inorganic nutrient resources are important in this context. For example in cases of nitrogen uptake by legumes like soybean and alfalfa as well as flowering plants fabales and rosales, direct nitrogen fixation takes place from atmosphere via symbiotic nitrogen fixing bacteria cyanobacteria and rhizobia associated with roots. However it is believed that both these microbes are attracted by exudates sugars and flavonoids respectively (Delaux, Radhakrishnan, *et al.* 2015). The non-symbiotic or free-living nitrogen fixing bacteria like Azotobacter, Clostridium, Klebsiella are perhaps the basic nitrogen contributors to crop plants. For example azotobacter organism has been reported from the rhizosphere of a number of crop plants such as rice, maize, sugarcane, bajra, vegetables and plantation crops (Arun. 2007). Similarly contributions of phosphorus solubilizing, and zinc and silica solubilizing microorganisms Bacillus subtilis and Bacillus sp to plant health are well known. Pseudomonas fluorescens is known as a PGPR (Plant Growth Promoting Rhizobacteria).

Despite so much contribution to plant health and growth, the word bacteria has been almost associated with human diseases; for example titles of some papers are: Pseudomonas fluorescens as a potential pathogen: adherence to nerve cells (Picot, *et al.* 2001), In vitro susceptibility of Bacillus sp to selected antimicrobial agents (Weber, *et al.* 1988), Bacillus subtilis: identification and safety (Cartwright, *et al.* 2009) etc. Therefore conceptualization of phenomena related to microbe-mineral interactions in context of flora might lead to better understanding of roles of microorganisms in fauna particularly human being.

#### Generalization of Microbe-Mineral Interaction Phenomena

Some of the known generalizations of microbe-mineral interaction, phenomena are as follows-

1. Grosh's hypothesis (evolution context): Microbes, by facilitating extensive hydrothermal alteration of the earliest oceanic crust through bio-alteration, promoted mineral diversification and may have been early architects of surface environments and microcontinents on young Earth (Grosch, *et al.* 2015).
2. Lopez-Guerrero's buffet hypothesis (bacterial nutrition context): There is large diversity of potential nutrients (rhizodeposits, root exudates, seeds, decaying organic matter, soil and the rhizosphere community itself) for microbes at rhizosphere as if it were a buffet where commensals (individuals of an association who whether benefit or not but never harm each other) choose their food from a diversity of option (Lopez-Guerrero, *et al.* 2013).
3. Gadd's hypothesis (bioremediation context): Bioremediation, the application of biological systems to the clean-up of organic and inorganic pollution with bacteria and fungi, is possible because microorganisms are capable of reclamation, immobilization or detoxification of metallic and radionuclide pollutants (Gadd, *et al.* 2010).
4. Reynolds' niche differentiation hypothesis (plant nutrient partitioning context): Because soil nutrients occur in different chemical forms, different enzymes are required for plant access to their nutrients, and soil microorganisms are a major source of these enzymes; plant nutrient partitioning arises from differential associations of plant species with microbes able to access different nutrient pools (Reynolds, *et al.* 2003).

Despite being as hypothesized architects of earth surface environments, commensals in buffet at rhizosphere, cleaners of manmade pollutions on earth and providers of nutrients to plants of their choices, the microbes are still conceived as pathogens since mid nineteenth century when Louis Pasteur, on the basis of a set of observation, hypothesized that germs (microbes) are the cause of infectious diseases. The other set of observation, not proving pathogenic character of microbes, too is not exceptional and is associated with immune strength.

### Hypothesis: Microbes Play their Roles in Fauna as they do in Flora

The microbes are [1] as conceived by Lopez-Guerrero, commensals in buffer at rhizosphere, [2] as conceived by Gadd, cleanliness lovers and [3] as conceived by Reynolds, benefactors of host plants. The author of this paper proposes the Hypothesis: Microbes play their roles in fauna as they do in flora. By Corollary that means microbes are commensals in buffet at animal and human digestive tracts, obviously love cleanliness and do all the best for their host.

### Hypothetical Theorization and Discussion

Perhaps the role of microbe that is often called pathogen in context of its pathogenic behavior is hidden in the immunization techniques called inoculation and vaccination. The question arises why a person is purposefully inoculated or infected to induce immunity in a controlled way even when he or she is already infected of the so called pathogen and why a healthy person is vaccinated by administering dead or weakened pathogens (so called) in the name of preventive measure. It means, the so called pathogen might be truly in the role of immune system strengthener for existence of biosphere in environment. However it is just a logic, in the light of which the hypothesis might be justified. In other words, it is an attempt of hypothetical theorization. But exactly the hypothesis testing, on experimental grounds, is required.

### Conclusion

The hypotheses of Grosch, Lopez-Guerrero, Gadd and Reynolds, in context of microbe-mineral interactions at rhizosphere, provide the new amplitudes of microbial studies. In the light of these hypotheses, it might be hypothetically concluded that microbes are benefactors of hosts, both the animals and the plants. The concept of pathogen seems to have concerns with limited circumference of observations made by Louis Pasteur in nineteenth century. It might be a theme for research whether eradication of microorganism species in the name of eradication of infectious diseases is beneficial for humans if not for entire biosphere.

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