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**Contact:** Executive Editor, Shrishti Eco-Research Institute, B-106, Devgiri, Opp. P. L. Deshpande Garden, Near Ganesh Mala, Pune - 411 030. India. Phone: 91-20-24253773 /Telefax: 91-20-66206539

Website: [www.seriecotech.com](http://www.seriecotech.com) Email: [seri\\_news@yahoo.co.in](mailto:seri_news@yahoo.co.in)

**Point for discussion this month** **Socio-microbiology - the Quorum for Bioremediation**

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## Eternal Words

*There is a sufficiency in the world for man's need but not for man's greed.*

*~Mohandas K. Gandhi*

*The system of nature, of which man is a part, tends to be self-balancing, self-adjusting, self-cleansing. Not so with technology.*

*~E.F. Schumacher, Small is Beautiful, 1973*

*"We - human beings - are part of 'biodiversity.' We are dependent on the whole food chain down below us."*

*- Darrell Merrell, heirloom vegetable farmer*

## Socio-microbiology – the Quorum for Bioremediation

- Sandeep Joshi

Dear Readers,

Pioneering application of ecotechnological treatment systems in the last decade of 20<sup>th</sup> century was a very logical sequel of thoughts of SERI's Green Surgeon Sandeep Joshi to yield the desired outcomes of the pollution elimination. His article in this issue on "Socio- microbiology" based on the communication among the individuals' or groups of microbial communities. It's a tiny world of microbes full of all competition, friendship, cheating and making life sustainable. This happens because they have molecular mechanisms of communication, regulation termed as quorum sensing and signaling.

Sandeep is at his marvel to explain the microbial interactions of ecotechnological processes.

As usual, this year also SERI participated with National Women Organization (NWO) of Mrs. Rama Rauta - a very active member of national Ganga Basin Authority (NGRBA) on the occasion of death anniversary of Mahatma Gandhi ji - Father of Nation India.

Two Judges – Ex-chief Justice Chandrasekhar Dharmadhikari, Ex-Justice Kolse Patil, eminent scientist Dr. Vijay Bhatkar and IIT professor Dr. Shyam Asolekar expressed concerned about killing of rivers by urban encroachment, exploitation and pollution.

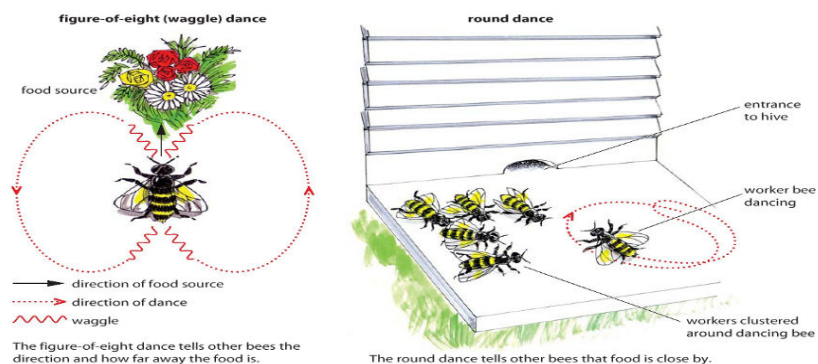
Thank you,

Chief Editor

Quorum sensing (QS) is a communication system of microbes to synchronize their activities, which allows them to function as multi-cellular systems for a particular task. This socio-behavioural-communication pattern can be engineered for wide ranged applications including bioremediation. QS System is found to useful for tiny microbial communities to regulate the formation and dispersion of intra-species or hetero-species individuals depending on conduciveness of the environmental conditions for survival or multiplication. Many studies in past 2 - 3 decades have confirmed that microbial cells secrete QS signals to affect the behavior of neighboring cells in a consortium via engineered cellular communication.

Social insect colonies are an excellent example of QS for decentralized system - a real natural democratic process of decision-making because no individual directs or makes decisions for the entire group or colony or consortia. Through extensive studies like scientist N. R. Frank did in last decade on ants, several groups of social insects are reported to use quorum sensing in a process that resembles collective decision-making. Colonies of the ant *Temnothorax albipennis* layer in small crevices of the rocks. When their nest breaks open, they must move quickly to a new nest. Scouting ants find a potential location assessing the quality of the crevice for nesting based on a variety of factors including the size of the interior, the number of openings (based on light level), and the presence or absence of dead ants. On returning to the destroyed nest, the scout ant will wait for a while other workers to follow her to the nest she found, using a process called tandem (trail) running.

This waiting period is dependent on the quality of the site. After thorough assessment of the potential nest site, the number of ants visiting the crevice increases. In due course, the ants at this new nest location sense that the rate at which they are encountering others has exceeded a particular threshold, signifying that the quorum number has been reached. Sensing the quorum, they return to the damaged for rapid shifting of the brood, queen, and fellow workers to the new secured place. Scout ants tandem-running to other potential sites are also employed in shifting the nest, and the entire colony moves! Thus, without spending a lot of time in assessing all the options by everybody, quorum sensing enables the insect colony as a whole to quickly make good decisions about where to move.



Entomologist like Seeley, T.D. and Visscher, P.K. studied the behaviour of honey bees (*Apis mellifera*) for using quorum sensing to make decisions about new nest locations. The queen leaves the hive with a group of some worker bees to form a new nest elsewhere. The worker bees form a swarm that hangs from a branch or any other structure. This swarm lasts during the decision-making phase until a new nest site is selected. The quorum sensing process in honey bees is somewhat similar to *Temnothorax* ants. A small portion of the workers break from the swarm to search out new potential nest sites. Each worker assesses the quality of the cavity it finds. On returning to the swarm, it recruits other workers to her cavity using the 'waggle dance' technique to attract others. Workers that found poor nests stop dancing sooner. As the visitors to a new site realize that a quorum number (usually 10–20 bees) has been reached, they return to the swarm. Then they start using a new recruitment method - piping. This quivering signal causes the swarm to take off to the new destination.



In short, quorum sensing functions as a decision-making process in any decentralized system about the niche's suitability, having means of assessing the number of other components they interact with and a standard response once a threshold number of components are detected. It is a system of stimulus-response related to population density. Many

species of bacteria are found to use quorum sensing to match up gene expression according to the density of their local population. Some of the best-known examples of quorum sensing are derived from the studies of bacteria. Bacteria are found to

use quorum sensing to harmonize certain behaviours based on the density of bacterial population. Quorum sensing may occur among the individuals of single bacterial species as well as between different species also. They can adjust a host of different processes, serving as a simple communication network. A variety of different molecules can be used as signals (Quorum Signaling). Familiar classes of signaling molecules are oligopeptides in Gram-positive bacteria, N-Acyl Homoserine Lactones (AHL) in Gram-negative bacteria, and a number of auto-inducers in both Gram-negative and Gram-positive bacteria.

Bacteria are increasingly documented as greatly interactive organisms with complex social lives as the research in microbiology is progressing. These interactions are critical for their phenotypic expressions, survival and multiplication. Many species inhabit dense, surface-bound communities, known as *biofilms*, within which they communicate and respond to local cell density through a *quorum sensing*. The genetics and biochemistry of biofilm formation and quorum sensing, is being explored to develop applications of molecular biology for better living of human being. It is found that many bacteria use quorum sensing and signaling (QSS - Q2S) to regulate the secretion of sticky extracellular slime, an integral feature of biofilm life. Mysteriously, it is noticed that some pathogenic species turn on slime production at high cell density, whereas others turn it off.

Bacteria have enthralling and assorted social lives. They exhibit synchronized group behaviours controlled by quorum-sensing systems detecting the compactness of other individuals or groups around them. A prominent illustration of such group behaviour is biofilm formation, in which communities of cells attach to a surface and envelope themselves in secreted polymers. After reaching threshold cell density, some species activate polymer secretion, and others terminate polymer secretion. Benefit of activating polymer secretion is very simple to allow individuals or strains to push into nutrient-rich areas and to outcompete, smother neighbouring cells. Variation in quorum-sensing behaviour can be linked to the differing requirements of bacteria in chronic versus acute biofilm contemplation of bacterial action in infection or natural detritus food chain. The balance of competition for food or the need for degradation of non-nutritive molecules within and among biofilms is the fundamental basis in the evolution of quorum sensing.

Generally, bacteria form complex bacterial communities in biofilms adherent to an abiotic and biotic surface, an interface, or to each other. Biofilm has unique feature of population distribution within biotone of the unit. This depends on quorum sensing processes which allow bacteria to display a unified response advantageous to the population by providing more favourable environmental niches and access to



nutrients while facilitating tolerance to stress. Biofilms on surfaces have a distinguishing configuration consisting of well-spaced micro-colonies enclosed in a hydrated matrix of proteins, nucleic acids, and polysaccharides. In this multifaceted micro-network, the cells act more as a collective living system with channels to deliver water and nutrients to the cells at the inner portion of the biofilm. Biofilm organisms are appreciably more resistant to environmental stresses and toxicities of chemicals than individual floating cells. Bacteria exhibit such numerous social activities. This social behaviour has its script written in the genetic level leading to sociology of microbes - 'socio-microbiology'. This genetic basis of QSS may be harnessed to control these communities of associated cells for bioremediation applications.

Bioremediation of wastes employs microbes of detritus food chain to remove, detoxify, or immobilize pollutants and convert them into utilizable forms. There is no requirement of addition of harmful chemicals to treat the waste. Bioremediation is absolutely appropriate for large areas where contaminant concentrations are comparatively low and the hydrodynamics of wastewater does not support an aggressive mechanical-chemical or mechanical-biological remediation strategies for numerous priority pollutants, including chlorinated hydrocarbons, poly-aromatic hydrocarbons, and heavy metals. Optimization of bioremediation processes requires a thorough knowledge of biofilm structure, dynamic, and interaction with pollutants and other environmental factors while employing them effective in field applications. Thus quorum sensing and social interactions in microbial biofilms have applications in disease control, soil bio-fertilization, bioremediation of wastewaters and contaminated soils, and microbial fuel cells etc. Microbial communities play in both maintaining and improving the ecological health of freshwater rivers and streams. Actually, it is the basis of ecological engineering and ecotechnology for the In-Situ Ecological Operation (ISEO) of highly polluted rivers and lakes!

## Workshop on "What we must do to save rives of Maharashtra"

- SERI Team

A one day seminar on what we must do to save the rivers of Maharashtra was jointly organized by National Women Organization (NWO), Shrishti Environment and Sustainable Society (SESS), SERI, Jalbiradari, Pune at Gandhiji National Memorial, Agakhan Palace, Pune on 30<sup>th</sup> January 2013 to pay tribute to our beloved Bapuji on the occasion of his death anniversary.

Various local NGO's and experts involved in river-conservation/river-pollution prevention works, Municipal Corporation members, Pollutions Control Board members and other government officials and interested local eminent personalities from different streams of life took active participation in the seminar and had free, frank and open critical discussions on various aspects of the issue.

The workshop was begun with prayer and lighting of lamp by dignitaries on dais. Mrs. Rama Ravta, Expert Member, NGRBA, Govt. of India and President, NWO, Pune welcomed everyone and introduced about program. After paying tribute to Bapuji; Key Note address was given by Dr. Shyam Asolekar, IIT Mumbai, Member, GRBMP, Govt. of India. He shared his experience in Ganga River basin management.

Hon'ble ex-Justice B. G. Kolse Patil and Ex- chief Justice Dharmadhikari, explained legal structure and role of working policy making in view of conservation of rivers .But at same time they stated that though India has good constitution, implementation of laws are plight since origin.

In afternoon session a panel discussion was organized, the session was chaired by eminent scientist Dr. Vijay Bhatkar and Hon'ble Ex-chief Justice Dharmadhikari.

Dr. S.N Kaul, Hon'ble ex-Justice Kolse Patil, Mrs. Rama Ravta, Dr. Shyam Asolekar, Dr. Amar Supate, Vinod Bodhankar, Shri Bandatya Karadkar Dr. Kuruvilla were participated as panelist .Discussion was coordinated by Dr. Sandeep Joshi.

The discussion was well focused on the status of rivers of Maharashtra and different activities carried out by individuals or organizations for restoration and conservation of rivers. A demand of formation of high powered Maharashtra River Conservation Authority (MRCA) for planning, financing, monitoring and coordinating to insure effective abatement of pollution and conservation of its rivers through comprehensive holistic planning and management. A resolution was passed in this workshop which was send to the Hon'ble Chief Minister as an appeal to save the rivers of Maharashtra.

Some points strongly recommended the resolution were:

1. Adopt the policy of zero discharge into the river
2. Promote organic farming to decrease the non-point sources of pollution of rivers
3. Industries must treat their effluents and use only the recycled water

### Glimpses of Gandhi Seminar Programme: 30<sup>th</sup> Jan. 2013



From Left to right Mrs. Rama Rauta , Ex-Justices Kolase Patil, Ex-chief Justice Chandrasekhar Dharmadhikari Dr. Shyam Asolekar



Sayali Joshi during panel discussion



Vinod Bodhankar explains the work carried out by different NGOs in Pune



Welcome Speech by Rama Rauta



From sitting Left to Right Dr. Vijay Bhatkar , Justices Kolase Patil, Ex-chief Justice Chandrasekhar Dharmadhikari Dr. Kaul



Mrs. Asha Verulkar sharing her experience

