Microbes and their Role in Sustainable Development

R. C. Kuhad

© Association of Microbiologists of India 2012

It is indeed a matter of great pleasure and honor for me to speak to you. I feel privileged to be president of the Association of Microbiologists of India (AMI). The year **David Baltimore was born**, who later on won Nobel Prize for medicine in 1975 for discovering reverse transcriptase, a DNA polymerase enzyme that transcribes single stranded RNA into double stranded DNA, **Max Theiler also developed a Vaccine against yellow fever** and got **NOBEL PRIZE** in 1951 and **Hans Christian Joachim Gram died**, who developed method for distinguishing two major classes of bacteria, the AMI was established. AMI started its own journal “Indian Journal of Microbiology” in 1960. Except some problems from 1961–1969, since 1970 AMI and IJM both have slowly and steadily consolidated their positions. The financial positions of the association improved steadily, its all because of the hard work of all the office bearers since 1969. The association is holding its annual conferences,

elections and auditing of accounts regularly. AMI has been served by 44 Presidents, 14 General Secretaries and has organized 52 Conferences. It gives an immense pleasure to announce that Association has over 3000 Life members and 50 AMI units spread all over the country and without doubt is one of the largest scientific organization.

The efforts continued to strengthen AMI and during last 5–6 years AMI has taken following remarkable decisions:

1. AMI decided to get its journal (IJM) published by Springer w.e.f. the year 2007 and AMI has been getting royalty. IJM has got an impact factor of 0.938.
2. AMI has increased the strength of Central council (CC) from 4–6. Interestingly, now CC has representation of two woman microbiologists.
3. AMI has doubled the award money w.e.f. 2010 for all the awards and the awardees and FAMI are provided 3rd A. C. train fare.
4. Since 2010, AMI has instituted Life Time Achievement Award for distinguished teachers and or researchers and their contribution to AMI and popularization of microbiology. This carries a cash prize of Rs. 30,000/-, citation and traveling grant by economy class.
5. The AMI has already started traveling corpus with minimum amount and it will initially be used for supporting the Young Microbiologists for their participation in AMI's Annual conferences and it is planned to extend this facility for participating other National Conference/Seminars.
6. AMI has also taken initiative to support organization of Seminar/Symposium/Colloquium/Quiz for popularizing microbiology in schools/colleges etc.
7. AMI has taken a decision to support AMI units for their activities with a cap of maximum grant of Rs. 20,000/- but once in 2 years, provided the unit submits

R. C. Kuhad (✉)

AMI, Lignocellulose Biotechnology Laboratory, Department of Microbiology, University of Delhi South Campus, Benito Juarez Road, New Delhi 110021, India

the detailed proposal to the G. S. Moreover, AMI has also started awarding AMI units (1st, 2nd and 3rd awards) annually based on their annual activities.

8. Our another continuous effort which took almost 5 years (since 2005), became a reality, that AMI has started its own Indian Academy of Microbiological Sciences, which is in process of registration. From the year 2012 the Academy will be electing its fellows as FIAMS. It has also been decided that all FAMI will automatically be the Fellows of the Academy. A corpus of over Rs. 5.00 lakhs has been allocated for the Academy. Thus development of the Academy is a landmark in the history of AMI. There will be intact association of IAMS with AMI.
9. We have succeeded in getting permanent office of AMI at Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Sonapat. The AMI central office will be in operation soon.

AMI has played commendable role in promotion of microbiology and it has provided a platform for young and established academicians to interact and learn more about the advanced researches in microbiology.

AMI stands for All Microbes Important or All Microbes Interesting—It depends how you see them and how they behave.

Microbes are everywhere and often in very large numbers. One can think of microbes beyond the world in which we all live (i.e., from earth to space). Microbes are an integral part of biogeochemical cycles which are important for our sustenance. A large number of these microbes are beneficial to plants, animals and humans in one form or the other but some are harmful as well.

Dear Delegates “Microbes generate more than half of the oxygen we breathe”. It is not an exaggeration to state that life originated with microbes and all life is derived from microbes. Life without higher organisms is possible, but life without microbes is not. Thus without going into detail of microbial ecology, I can say that microbiota of an ecosystem has the capability to keep its environment clean, provided it's not overloaded with the pollutants.

Microbial world, a treasure in itself, if exploited judiciously, can contribute to the sustainable development. According to me there are three super challenges of the 21st century: (1) climate change, (2) food security, (3) dependence on imported petroleum, and I think microorganisms are efficient enough in meeting out these challenges.

Microbes and Climate Change

The ongoing global climate changes caused by increase in green house gases represent one of the biggest scientific

and political challenges of the 21st century. As per the informations available, the anthropogenic CO₂ production is currently of major concern. Yet it represents only 10 % of the CO₂ produced normally by soil. Sustainable agriculture permits the build up of humus in the soil in order of 0.3–1.0 tons carbon per hectare per year. This way, about 10 % of all carbon emitted by vehicles can be compensated by applying good agriculture. In addition, the microbial dynamics as a function of temperature and *p*CO₂ are not yet fully understood. There is quite a possibility that changes in climate and land use can be compensated by the homeostasis of the microbial communities.

Soil microbiologists have an important role to play in the greenhouse gas issues, and this not only with respect to CO₂ but also in terms of N₂O and also particularly CH₄. They should emphasize the “services”, which are rendered by the healthy soil microbiota to society. It is well established that microbial ecology or environmental microbiology is involved in both formation and the removal of these gases. The rumen microorganisms are responsible for almost 30 % CH₄ emissions and novel approach about short circuiting the rumen methanogens by providing alternative electron acceptors such as herbal component are underway. The paddy crops are second important 30 % emitter of CH₄. Landfills are also reported to contribute another 15 % and in present scenario modern biotechnology of anaerobic digestion offers the possibility of capture these emissions and uses them to produce utilizable energy. However, role played by methanotrophs present in soil to the abatement of CH₄ cannot be overlooked. They scavenge on average in the order of 800–1000 kg methane per hectare per year. The researchers need to remember that they do not do such job in presence of fertilizers and pesticides. Globally the research in this area is progressing at a fast pace.

Indian research on climate change and feedback response centered around measuring the biogeochemical processes and determining the source–sink relationship to use the information on developing predictive climate models. Extensive studies on the microbial role on the process and the associated microbial diversity have been worked out. Central Rice Research Institute, Cuttack had been in the forefront of such studies on the microbial involvement on the process. Research studies from this institute has been focussed around the studies on the microbial diversity associated with basic microbial processes and several new nitrifying and denitrifying bacteria have been identified. Studies on diversity of methanotrophs are going on at the Department of Botany, Banaras Hindu University, Varanasi and, the photosynthetic bacteria are being worked out at the Jawaharlal Nehru Technological University, Hyderabad. However, according to expert's view, our understanding about microbial response to climate change remained limited and our knowledge on

climate change and feedback responses by terrestrial microorganisms needs to be strengthened. There is an urgent need to generate information on the structure and bio-geographical patterns of microbial communities including the functional relationships between microorganisms and plant communities.

The impact of climate change on the applied aspects of crop production and productivity and the role of associated microorganisms on the mitigational impact of the microorganisms on plants are being studied in several laboratories. Central Research Institute on Dryland agriculture (CRIDA), Hyderabad is doing extensive research on the role of PGPR on mitigating the adverse impact of climate change like high temperature stress and associated drought and imparting other stress tolerances including production of biofilm by rhizosphere microbes. Additional input is being provided by other two laboratories at IARI, New Delhi and CRRI, Cuttack. Several other centres of studies like at Pantnagar, National Institute of Abiotic Stress Management at Baramati have also initiated research studies in this direction. CSIR institutes like NEERI and NBRI are also actively engaged in environmental management studies.

Food Security

The world population is increasing uncontrolled, as 7 billionth baby has taken birth on 31st October 2011 in Uttar Pradesh and Philippines. More alarmingly population rise is a major concern of our country. As per estimates Indian population will touch to 1.3 billion by 2020 and will require more than 300 million tones of grains. Thus there is need of many green revolutions like one we had in late sixties. The constant researches in the area of agricultural microbiology have proved that microbial fertilizers/bio-pesticides/bioherbicides can contribute significantly in improving the crop productivity. The Indian institutions have done commendable work and developed technologies for p-solubilization, N₂ fixation and more recently some groups have concentrated on application of endophytes in maintaining arid ecosystem.

It can be rightly said that microbes—a goldmine for biofertilizers, but unfortunately, the biofertilizers are not widely utilized by farmers, which could be because of lack of awareness among masses. The soil microbiologists have the responsibility to promote such products selecting various communications, advertising vectors and training programs. In addition to this there is strong observation among experts and users that to practically improve plant productivity there is need to follow an integrated management system.

There is no doubt that use of modern technology/bio-technology has boosted the agricultural production but

most of our foods and food grains are spoiled because of either poor storage facility or non-availability of storage facility. This area needs more attention of the researchers and agriculture ministry. More detailed study about food spoilage microbes and to develop more feasible and need based food preservation methods or facilities are required.

Other Biotechnological Approaches for Food Security

A lot of research is going on about beneficial role of probiotics for human health, developing novel food products and processes, rapid detection kits for GM foods, utilization of agricultural residues for obtaining value added products and low cost nutrient food supplements. Some examples are as follows:

- *Bacillus* sp. ST13 has been reported to produce catecholate type siderophores under *in vitro* iron limiting conditions. It has shown antimicrobial activity against enteric pathogens like *Salmonella typhimurium*, *S. pyogenes* and *S. aureus*. The bacterium was observed to be suitable for human application after safety studies.
- Lactic acid bacteria isolated from traditional fermented foods of Manipur (Soibum and Soidon) has shown antimicrobial activity. Especially soibum has been reported to have many health promoting benefits.
- Multiplex PCR-based detection assays have been developed for a range of GM crops for rapid detection of genetic traits in selected plants like GM Brinjal, GM Potato and GM Cabbage.

As food quality is important, but safety is also a matter of equal concerns:

- Recently a microchip has been designed and fabricated for detection and identification of food pathogens.
- PCR based method for detection of adulteration in turmeric and Chilli powder has been developed.

Other areas of research where microbes contribute in producing healthy and nutritious foods e.g. algal and fungal protein. *Spirulina*, button and oyster mushrooms are already cultivated on large scale. Other beneficial mushrooms; *Lentinula edodes* (Shiitake), *Calocybe indica* (Milk mushroom), *Cordyceps sinensis* (Insect mushroom, Kirajali), which are pharmaceutically more desirable but their cultivation needs more R&D. Recently in our country a protocol has been developed for *L. edodes* cultivation using rice straw as substrate.

The agricultural products alone can not meet the food demand, therefore the research on the animal productivity holds equal importance. Microbes can really contribute in improving the animal feed for ruminants and non-ruminants. The white rot fungal fermentation of wheat straw has improved its protein content and digestibility. Lignocellulose

Biotechnology Laboratory, University of Delhi South Campus in collaboration with IIT, Delhi and Ayurvet Pvt. Ltd., Delhi has achieved success in developing animal feed. Some groups in India have been working on the application of xylanases and phytases in improving the grains and converting keratin substrate with keratinases into feed for poultry and piggery. The work in these areas needs more efforts and government support to transform the R and D into commercial viable technology.

Dependence on Imported Petroleum

Other greatest challenge in the 21st century is to meet the growing energy demand world over and reduce the dependency on imported petroleum. The future risks of global warming, depletion of oil reserves and environmental concerns promote the production and usage of alternative fuels; bioalcohols. The ethanol is economically produced from sugarcane and corn in Brazil and America, respectively, but because of food security, feed based resources can not be used for long and eventually reliance moved to non-feed resources, plant residues (the ligno-cellulosics). To make ethanol bioprocessing from ligno-cellulosics economically viable needs intensive research in the areas like:

- Developing cost effective and environmentally benign pretreatment.
- Minimizing the toxins in sugar syrups.
- Economization of enzymatic hydrolysis.

Improving cellulases production.

Use of hemicellulases, specially esterases.

Use of laccases to improve sugar yield.

- Developing C5 and C6 sugar fermenting recombinant.
- With the development in ethanol production and its utilization as biofuel recently, a new area of research has emerged i.e., environmental life cycle assessment (LCA) of lignocellulose to bioethanol production and this should be included in our biofuel programmes.

Currently several R&D projects as well as pilot plants and demonstration projects on second generation bioethanol are being implemented worldwide. The demonstration plants are at different levels of maturity, few of them are in advanced stage (Abengoa, Inbicon, BioGasol), while others are still in the design phase. The pilot plant of SEKAB, located in Örnsköldsvik, Sweden has a capacity to produce 300–400 L of bioethanol per day from 2 tons of dry sugarcane bagasse. The demonstration plant of Abengoa Bioenergy in Babilafuente, Spain has the capacity to process 70 tons of agricultural residues per day and produce 5 million litres of bioethanol per year. The company

BioGasol has its pilot plant in the Technical University of Denmark, which has a capacity of 10 t ethanol per year. Inbicon, a subsidiary of the Danish DONG Energy, is also developing a second generation ethanol demonstration plant. While, in Canada, a shell station in Ottawa jointly run with Iogen, became the first in the country to serve cars with cellulosic ethanol, offering a 10 % blend of gasoline and wheat straw ethanol manufactured at a demonstration-scale cellulosic ethanol. Verenium, currently operates an integrated cellulosic ethanol pilot facility in Jennings, Louisiana.

According to a study up to 2008 in US the tentative cost of ethanol production has been \$ 0.66–0.66/L (spruce); \$ 0.67–0.86 (corn stover) and \$ 0.72–0.87 (salix). While, a European Union project called **REFUEL** projected the cost of ethanol as in 2010 (\$0.90/L), 2020 (\$ 0.85/L) and 2030 (\$ 0.72/L).

While in India, we are still in a stage of developing the process for ethanol production. Researchers at NCL, Pune, University of Delhi South Campus, New Delhi, ICT, Mumbai, NIIST, Trivandrum, IMTECH, Chandigarh and OU, Hyderabad are actively engaged in process/technology development for bioethanol production. Recently ICGER, New Delhi has also taken initiative to produce recombinant for hyper cellulase production and co-fermentation of C5 and C6 sugars. In addition to this some companies; PRAJ Pune, IOCL, Faridabad, TATA Chemicals, Mumbai, RELIANCE, Mumbai and DANISCO-INDIA, Hyderabad are in process of developing substrate based ethanol fermentation process and eventually putting a demonstration plant.

Other emerging areas of equal or of more attention for microbiologists are:

- Microbial diversity of desert ecosystem and their potential for biotechnological potentials.
- Bioremediation of polluted ecosystems and microbial technologies for waste management.
- Production of industrially important products e.g erythritol, xylitol, shikimic acid, microbial cellulose etc.
- Developing new classes of antibiotics.
- Microbes and their enzymes based biosensors for monitoring environmental/industrial and food samples.
- Nano-bacteria, their occurrence and diversity in the deep surfaces.
- High throughput screening of microbes and their bioprospecting.
- Metabolic engineering for improving yield and industrial products.
- Synthetic biology.
- Computational biology.
- Gene profiling using microarray.

Thus after illustrating a variety of roles played by the microbes, I would like to share with you about the report brought about by ASM, which states that:

- Since microbes are of fundamental importance to life, their activities must be taken into account in biological research and all biologists must have a solid background in microbial sciences.
- Microbiology should not be considered to be just another organismal biological sciences, but should be regarded as a foundation for all biologists, on the par with biochemistry, genetics, and the study of evolution.
- To make the best progress, microbiology must reach across traditional departmental boundaries and become integrated with other disciplines.
- The science of microbiology should not be confined to microbiology departments in universities. Microbiologists should have positions in other departments such as chemical engineering, earth sciences and given the importance of microbes in shaping human affairs, the humanities.

As President of AMI and an individual, I am fully convinced and endorse the ASM's view and put forward to all of you, especially to the scientists and scientific managers and educationists, who really can help in putting such recommendations in our government plans and policies. I also recommend it to the C. C. and G. B. of AMI to consider it as one of the vision and recommendation to be forwarded to the Ministry of HRD, Government of India, for consideration and implementation.

In addition to, the above I wish to take liberty to express my concern that this is the right time to think that where should AMI go in the 21st century? I put forward some issues for your consideration:

- With increase in travel cost and support money to AMI Units, should we encourage regional meetings to have better interaction between CC members and the units? This may also help AMI to use annual meetings for policy changes in AMI and microbiology in India and execution should go to regional meetings.
- Whether we continue establishing more awards or utilize the available funds in a best way for improving microbiology in India.

or

Can we think of establishing a research fund to support young microbiologists who have just got into jobs?

or

Can some money be used for enriching travel corpus to encourage one or two scientists to attend international conferences etc.?

- There is need to sit together and evaluate the present stats of microbiology today and where should it go in teaching and research. What improvement would you like to see in teaching microbiology in the time to come?
- Are you satisfied with the quality of our teaching microbiology in all universities? If not, can AMI think of doing something? This is a very important suggestion I put forward to CC members and next president and others to think about?
- Similarly in research, we have to evaluate the quality of research carried out by our youngsters and published in IJM? What improvements are needed? Can AMI organize counseling/training program or special session for youngsters during annual/regional meetings? We need to define the specific areas/expand the areas of national/global interest for example bioenergy, bioremediation/climate change microbiology/biotherapeutics/diagnostics. Research papers related to such areas should be preferred for publication in Indian Journal of Microbiology.

With this, at the end I would like to say that I follow “achieving through believing” and I don't have any intention of claiming the entire credit for doing what I could do as Treasurer, General Secretary and President of AMI but I was privileged to have dedicated central council members and all time support from the past Presidents, Presidents Elects and overwhelming support from members of AMI from all over the country and my well-wishers and above all the God's blessings.

Thank you all !!