Future models of green technologies for sustainable development

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There has been a lot of talk about global warming and climate change, and the requirement of preventive measures. There is a lot that man could learn from nature itself. Here a few suggestive measures in the form of cost-effective future models of green technologies for sustainable development are made.

(i) Employment of methylotrophs to absorb methane and thereby reduce methane emissions in paddy fields: Methane is considered to be one of the greenhouse gases (GHGs) and is produced in paddy fields. Reports mention that methane produced in rice fields is enough to add to global warming and bring about climate change. However, nature has a mechanism wherein the methane produced in rice fields could be utilized by the methanotrophs, thus maintaining a balance. Methanotrophs along with methylotrophs are a group of bacteria that could utilize single-carbon compounds aerobically and convert them into organic form. While the former could essentially use methane and other single-carbon compounds to grow, the latter can utilize multi-carbon compounds also, in addition to the single-carbon compounds. There is enormous amount of literature, including excellent reviews available on the diversity, physiology and ecology of methanotrophs and their role in mitigating methane levels in the atmosphere[1–4].

Studies focused on methane consumption by methanotrophs have indicated reduction of methane to significant levels[2–10]. Though methanotrophs have the capacity of converting methane into usable form, their numbers available in paddy fields at any given point of time may be less than what is required. The author's contention here is that, if need be, the load of methanotrophs could be enhanced several fold by producing the inoculum of a consortium of methane-consuming bacteria on a large scale and applying such consortia in rice fields, so that the methane emissions could be reduced at source itself. Such an attempt need not be restricted to rice fields alone, but could be extended to other methane-generating environments also. One has to look for other beneficial aspects of methanotrophs for such an intervention, which would be a bonus.

(ii) Cleaning of sewage water and generation of biogas from sewage: In India and probably in a host of other countries around the world, most of the non-perennial rivers are nowadays filled with sewage. The main source is urban sewage that has a run-off into these rivers. It is a different aspect that the perennial rivers getting contaminated with sewage and other unwanted discharge is not something new, but is not the topic of the present discussion. Examples of non-perennial rivers which were once a source of drinking water and for various other beneficial purposes in the past half century or so are Cooum, Adyar River and Buckingham Canal, in Chennai alone. There are several other rivers in India and elsewhere, which are facing similar problems. This problem is being tackled by different governments in different ways. Constructing cemented bunds on either side of the river in addition to laying canals on both banks to take the sewage directly into the sea without allowing it to enter into the river is not a new idea.

Now instead of letting the sewage into the sea, it could be collected at different points along the line and processed for methane generation. This could be done as follows: The sewage entering into the canal could be passed through a mesh or filters of different sizes so that the water could be free from solids and debris. Initially, a larger filter (pore size 1 cm) could be used to filter larger particles, including plastic, metallic remnants, etc. There should be a provision to remove the debris continuously and the debris could be incinerated. This first step of filtering could be followed by another filter containing pore size of 0.1 mm, which could be used (rotating-drum filter) to collect the solid particles. The solid particles (presumably organic) collected into a cemented tank in the second filtration could be used for methane generation. The key factor here is smaller solid organic particles of uniform size that are ideal for methane generation. In fact, as a third step, to reduce the total suspended solids another filter of the pore size of 0.01 mm could also be used to filter the sewage water before it is further processed. Using a magnet the unwanted metallic splinters could be removed from the solids of the second and third steps.

The liquid part that passes through the third filter could still have solids as suspended particles in the water. This could be sieved-off using pebbles and sand as the fourth step. In the final step, the water coming out should have only dissolved solids and no more suspended solids. Since the water has already been clarified to a great extent, the sewage water of the fourth step could be passed into the sea. Here again, there could be some more steps that could reduce the possibility of eutrophication, because higher amount of total dissolved solids could lead to eutrophication. For this, the sewage water could be passed onto large artificial ponds along the banks of the rivers, and monocultures or dual cultures of microalgae such as *Chlorella* and/or *Scenedesmus* could be grown on this water. The biomass from algae could be used for extraction of proteins, which then could be used as a feed for fisheries, aquaculture ponds, cattle or human beings. Alternatively, biomass of the algae could be sent into the anaerobic digester for biogas production. The other advantages of this step are that the algae could sequester carbon dioxide and fix it into sugars. Such an aspect would bring down the levels of CO_2 and provide us carbon credits. The carbon dioxide released during methane generation could be recharged into this algal pond.

The methane generated from the second step could be connected to a turbine to generate electricity. If most of the operations as mentioned above are based on the gravitational force mainly during filtration stages (filtration steps 1–3), then no external energy is required. But it depends on the elevation of sewage running into the river and the sea level. If the design has to depend on mechanical pumping, then it would consume energy. The energy produced through methane generation could be used for various operations of this intervention, so that entire operation is self-sufficient and does not require any expenditure. In fact, it could be a profitable intervention also. However, actual calculations have to be made. The excess electricity could be sold to the Electricity Board and the money received could be used for the repayment of loans taken for the construction of bunds, sewage canals that connect to the sea, and for pond constructions, etc.

The slurry coming out of the biogas digester could be used as manure for agricultural crops. In general, during anaerobic digestion most of the pathogenic bacteria are knocked-off. The enormous amount of literature on anaerobic digestion of cow dung is a testimony to this. The same logic could be extended to sewage solids also, that mainly contain human excretion. Initially there may be some resistance to the application of slurry of biogas digester coming from the sewage, since it comes from night soil. In that case the slurry could be applied in wastelands, dry lands and arid regions.

Alternatively, the slurry could be used as inoculum for methanogenesis of solid waste collected from urban areas and dumped at several places. In fact, the solid organic waste, if properly segregated at source, could be churned out to get uniform particle size and fed into a digester and the slurry from the sewage anaerobic digester could be added to the urban waste for methane generation. Transport charges for carrying slurry in 100 l cans will be another area where money will be spent. If each litre of slurry is sold at one rupee, the transport charges could be covered from this.

The above work could be directly taken up for implementation by the corporations of different cities with calculations; the vital engineering and microbiological aspects, various designs of tanks, etc. could be decided once the major idea is accepted.

(iii) Sewage water for reclamation of desert lands: Instead of releasing sewage water into the sea, it could be routed into the desert lands. Over a period of time the chances of plant growth would increase. There may be possibilities of pathogenic microbes entering the desert soils if sewage is let into the desert lands. However, such microbes would die due to excess heat that prevails in the desert lands. The only exception could be spore-formers. Even these could die after one or two rains, as the spores would germinate and turn into the vegetative stage. The microbes thus turned into the vegetative state would die upon re-exposure to excess heat in the deserts. By following the above method, enough organic and inorganic loads would reach the deserts. One disadvantage of the above scheme would be the requirement of long pipelines for transport of sewage water and energy inputs if it has to be mechanically pumped from the sewage water system to the deserts. Though seemingly this is an energy-intensive measure, it would be an environment-friendly programme, which on the one hand cleans the environment and on the other provides water and minerals required for plant growth in the deserts. In the long run a desert could be converted into pristine forest. It seems that such attempts are being made in Brazil.

(iv) Multiple cropping to increase agrobiodiversity and to sequester carbon dioxide more efficiently in farmlands: This aspect has already been discussed earlier in this journal[11].

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