DEVELOPMENT OF NEW BIOGAS TECHNOLOGY PROVIDES INSIGHT INTO AGRICULTURE

DR A D KARVE
Appropriate Rural Technology Institute, Maninee Apartments, Survey no. 13, Dhayarigaon, Pune

ARTI (Appropriate Rural Technology Institute) developed a compact biogas system, which uses feedstock in the form of sugar, starch, protein, fat, or cellulose. It produces 1 kg biogas per kg (dry weight) of feedstock, taking only about 24 hours to complete the reaction. In the traditional dung-based biogas plant, one requires about 40 kg dung and a reaction period of almost 40 days to produce the same amount of biogas. The reason behind the high efficiency of the compact biogas plant is that the methanogenic bacteria work more efficiently if they are provided with feedstock with a high nutritional calorific value. This insight helped the author in understanding the logic behind a new agricultural practice being followed by some farmers in Peninsular India.

Thousands of farmers in India's Peninsular region apply 25 kg of jaggery (non-centrifuged sugar) along with 25 kg of cattle dung and 25 litres of cattle urine per hectare of their fields once every three months. Some farmers even add butter fat to this mixture. These ingredients are mixed with 500 litres of water. After storing this mixture for a few days, it is poured, tumbler by tumbler, on the soil surface or into the irrigation water. This procedure is locally known as Amritpani (elixir water).

The practitioners of Amritpani apply neither chemical fertilizers nor organic compost to their fields, and yet, they get very high yield year after year. This fact was verified by the members of ARTI after interviewing the farmers who followed the practice. This exercise revealed that the farmers not only obtained high yield but also that their use of pesticides had come down drastically.

One of the interviewees, Mr Bhaskar Save of Village Umbargaon in Valsad District, Gujarat, does not use Amritpani but applies only 125 kg of green leaves per ha (about 25 kg dry matter) to his field. On dry weight basis, green leaves have the same calorific value as sugar, if the concerned organisms are able to digest cellulose. Mr Save used to apply chemical fertilizers to his field, but gave them up when he noticed that year by year his crop yield and profitability were declining. He first experimented with organic farming in the traditional way—applying 20 to 30 tonne of composted biomass per

ha of his field. But, he soon realised that it was a costly method. Eventually, he evolved the method of applying a relatively small quantity of green leaves to his field, which represented a high calorie, non-composted biomass. According to Mr Save, the profits from his farm soared as soon as he switched over from chemicals to green leaves. The advantage of this method is that green leaves cost nothing. They are either plucked from plants growing in and around the farm, or one just buries the weeds into the field after weeding.

There is universal agreement among agricultural scientists that soil micro-organisms play an important role in maintaining soil fertility, but the nature of the activity is not yet clearly understood. The mineral components of the soil exhibit an extremely low solubility in water. There is no mention in technical literature of soil micro-organisms enhancing the solubility of minerals through chemical degradation or extra-cellular digestion of the minerals. Textbooks mention oxidation of reduced compounds of nitrogen and sulphur into nitrates and sulphates, and chelation of certain divalent cations to make them more readily available to plants.

It is also mentioned that some micro-organisms produce organic acids, which dissolve carbonates and phosphates in the soil. But the silicate minerals, which constitute the major part of the soil minerals, are not affected by any of these reactions. It is generally assumed that micro-organisms contribute to the soil fertility mainly through decomposition of organic matter to release mineral elements sequestered in it. There is no doubt at all that the micro-organisms decompose the organic matter in the soil, but it must be mentioned that not only the carbon but also the mineral elements in the organic matter are consumed by the micro-organisms.

The organic matter in the soil has its origin mainly in plant residues, which are very poor in mineral elements, because almost 95% of the plant biomass is made up of carbon, hydrogen, and oxygen. In fact, the plant organs like leaves, petals, and bark, which are naturally discarded by plants, have even less than 1% mineral elements in them. Therefore, these residues serve the soil microbes mainly as sources of carbon, with only a relatively small quantity of mineral nutrients, becoming available to the micro-organisms through decomposition of naturally occurring organic matter in the soil. Also, the availability of macronutrients from organic manure is not as fast as from chemical fertilizers because it depends upon the rate of their decomposition, which is controlled by the C:N (carbon–nitrogen) ratio, soil temperature, and soil moisture content.

It is postulated by the author that the minerals dissolved in the soil water serve as the source of mineral elements for the plants and the soil micro-organisms. Being held by capillary forces between soil particles, this water is called capillary water. The soil minerals have very low solubility in water, but the concentration of the dissolved minerals is in a state of dynamic equilibrium. The molecules and ions removed from the solution by the micro-organisms or plants are replaced by new ones entering the solution from the pool of minerals in the soil. It is due to this process, that a crop of wheat or rice can remove about 250kg of silica per ha annually. However, the minerals containing silica, namely quartz, opal,

or silicate minerals, dissolve in water to the extent of only 5 to 150 mg per kg.

The fact that green plants can grow anywhere on the surface of the Earth shows that soils at all locations have all the minerals needed by plants. The terrestrial plants have to hold a large part of their body in the air for catching light for photosynthesis. The only organs they have for absorbing water and minerals from the soil are the root hairs located at the tips of their roots. This fact, combined with the low solubility of soil minerals in water, reduces the efficiency of the terrestrial plants in absorbing minerals present in the soil naturally. Micro-organisms, on the other hand, absorb minerals through their entire surface, and being very small in size, they have a relatively large absorptive surface in proportion to their volume. They, therefore, absorb minerals from the soil solution with much greater efficiency than the terrestrial plants. The minerals absorbed by the micro-organisms get incorporated in the biologically useful organic chemicals inside their cells. After the micro-organisms die, the chemicals are released from the cells. Being water soluble, they are readily absorbed by the plants. This shows that micro-organisms in the soil are the primary absorbers of minerals and that they are the ones who make the minerals available to plants.

As it is an accepted fact that soil micro-organisms contribute to soil fertility, agronomists recommend application of organic matter to agricultural fields in order to increase the population density of micro-organisms in the soil. However, the organic matter is generally provided in the form of compost. The quantity of compost recommended for application ranges from 20 to 30 tonnes per ha, representing biomass grown in about 10 ha. As compost represents decomposed organic matter, it has relatively low nutritional value. Logic and common sense tell us that if the organic matter is to serve as food for the micro-organisms, it should have a high nutritive value.

In an experiment conducted by scientists of this laboratory, merely 500 mg (milligram) of pure sugar added to a kg of soil caused the bacterial population of the soil to increase by 500 times within a period of just 24 hours. Similar results were reported by other authors with pyroligneous acid (wood smoke condensate containing several organic acids) applied to the soil. No chemical fertilizers were provided to the soil in any of these experiments, showing that the micro-organisms were capable of taking the minerals directly from the soil solution and also, that extremely small quantities of high calorie organic matter could replace relatively large quantities of compost.

The fact that one can practise agriculture without chemical fertilizers by providing soil micro-organisms with food with a high nutritive value has a great significance for the global energy economy. The chemical fertilizer industry consumes annually 1.2% of all the energy in the world, which is greater than the energy consumed even by the steel industry. In addition to the energy consumed during the manufacture of the chemical fertilizers, energy is also consumed in transporting it from a central factory to millions of farms. All this energy and the expenses are saved by following the logic provided in this paper.