'Superbugs' make biogas from neat piggery waste

Piggery waste is rich in nitrogen and other elements, and makes good soil fertilizer, but it smells unpleasant and causes pollution if it escapes into rivers and creeks.

These drawbacks are generally overcome by running the waste into lagoons, where bacteria break down the offending organic compounds. At least some of these bacteria are aerobic — that is, they need oxygen to carry out their work of completely 'burning' organic matter to form carbon dioxide.

Economically, a more attractive way of treating animal wastes involves allowing bacteria to digest the waste in the absence of oxygen.

This treatment scores over alternatives because the bacteria do not completely oxidize the organic compounds, but instead generate 'biogas' a mixture of gases rich in methane and therefore valuable as a fuel.

Such anaerobic digestion (also called fermentation) is already popular in India and China as an inexpensive method of producing gas from cattle manure for home cooking and lighting. The higher protein content of piggery waste, however, presents a challenge.

Relative to their carbon contents, piggery waste contains almost twice as much nitrogen and five times as much sulphur as cow dung. The bacteria do not need all this nitrogen and sulphur, and they convert the excess to ammonia and hydrogen sulphide respectively, which inhibit methane production. For this reason experimenters have generally concluded that piggery waste must be diluted before digestion.

Mr Kevin Kirby of the CSIRO Division of Chemical Technology has proved this assumption false. His pilot plant, with a digester volume of 18·6 cu m, began treating undiluted piggery waste in October 1978.

The bacteria in this pilot digester survived ammonia and hydrogen sulphide concentrations that laboratory experiments had previously suggested would be lethal. How did Mr Kirby come by such 'superbugs'?

His trick was simply to allow the micro-organisms sufficient time to adjust to gradually rising toxicant levels. At first, he fed the digester only small amounts of waste. Six months elapsed before undiluted wastes were being efficiently digested. After a year the digester was loaded every day rather than 4–5 days a week.

Mr Kirby was in effect selecting the forms of bacteria most tolerant of ammonia and hydrogen sulphide; these survived and multiplied within the digester while the other forms died. After about a year the microbial population consisted exclusively of bacteria tolerating high toxicant levels, and cultures of these bacteria could in theory be used to establish other digester populations, with shorter initial delays.

The first full-size plant will handle wastes from 30 000 pigs.

Once the digester was running at full load it gave most satisfactory results, producing much more gas (approximately 2·0 cu m per cu m of digester volume) than any previous plant handling whole wastes.

Some of the biogas is burnt to heat the digester to its operating temperature of 35°C. Using raw wastes ensures that the quantity of gas required for digester heating is kept to a minimum: diluted wastes would demand more fuel.

Mr Kirby, who has been assisted by Mr Paul Arumets of the Division and supported by a grant from the Australian Pig Industry Research Committee, also developed a technique to maintain a high concentration of micro-organisms.

Before adding the daily 'feed' of new wastes, the researchers switch off the agitator that intermittently mixes the digester contents and allow the mixture to settle for an hour. Many of the bacteria in a digester are strongly attached to fragments of cellulosic fibre, and these settle and remain in the digester during feeding while the surplus liquid overflows into a tank.

This overflow is left to settle for a day, and then a portion of the settled microbial sludge is added to the next day's 'feed'. In this way many bacteria are retained in the digester, and a significant proportion of the rest are recycled.

Mr Kirby believes the plant could become yet more efficient if the fibrous fraction of the piggery waste is chemically modified before going into the digester.

Some of the cellulose in the raw waste is combined with lignin, which makes it inaccessible to bacteria. Mr

Kirby's laboratory studies show that the bacteria digest a higher proportion of fibre that has been heated with sodium hydroxide. This pretreatment is still being evaluated in the pilot plant; calculations suggest it should increase gas production by up to 40%.

The pilot digester.

Will such plants be expensive to run? Mr Kirby believes that the CSIRO design, being relatively simple, should prove cheaper than alternative methods of waste treatment in piggeries with a population of 1000 or more. Plans are already being drawn up for a full-size plant in Singapore.

This plant, being established through the Australian Development Assistance Bureau, will handle the wastes from an intensive piggery of 30 000 animals, using one or two digesters totalling about 3000 cu m. The biogas produced will be used to generate electricity for the farm and domestic use. Protein for stock feed may also be one of the by-products, obtained by harvesting micro-organisms that have grown in lagoons fed with settled waste and liquid from the digester.

The plant is expected to come into operation in 2–3 years' time.

Anaerobic digestion of piggery wastes. K.D. Kirby. In 'Australian Pig Manual'. (Australian Pig Industry Research Committee: Canberra 1979.)