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Microbial community diversity of organically rich cassava sago factory waste waters and their ability to use nitrate and N_2O added as external N-sources for enhancing biomethanation and the purification efficiency

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ABSTRACT

Water shortage necessitated South Indian sago factory owners, extracting starch out of cassava tubers, to install biogas plants where a starch utilizing microbial community multiplies and reduces the biological oxygen demand (BOD) of the waste waters by presently about 30%. The purification efficiency of sago factory waste waters, rich in solid particles and having wide C/N ratios, around 250, through unstirred biogas plants needs to be improved. Our approach was to apply instead of animal slurry nitrate (NO_3^-) and nitrous oxide (N_2O) as external N-sources anticipating a better N-distribution in the unstirred biogas plants.

Estimated cell numbers, bacterial community changes, on the basis of 16S rRNA gene clone libraries and changing CO_2-, CH_4-, N_2O releases due to the presence of nitrate or N_2O suggest that acid tolerant *Lactobacillus* spp. dominate the biogas plant inflows (pH 3.5). They were very less or not found in the outflows (pH 7.3). Assumingly, the phyla *Bacteroidetes* (*Prevotella* spp.), *Proteobacteria* (*Rhizobium* spp., *Defluvibacter* sp.), *Firmicutes* (*Megasphaera* spp., *Dialister* spp., *Clostridium* spp.) and *Synergistetes* (*Thermanaerovibrio* spp.), not-detectable in the biogas plant inflows, replaced them. Anaerobes, about 400 cells ml^{-1} in the inflows, increased to about 10^6 cells ml^{-1} in the outflows. The methane formation, as confirmed by the incubation experiments, suggests that methanogens must have been present among the anaerobes. In the biogas plant in- and outflows also about 300 cells ml^{-1} denitrifying bacteria and up to 10^4 cfu fungi were found.

Despite the low number of denitrifying bacteria nitrate added to the biogas plant in- and outflows was widely consumed and added N_2O decreased considerably. Thus, wide C/N ratios substrates like sago factory waste waters keep the N_2O emissions low by using N_2O either as electron acceptor or by incorporating it into the growing biomass what needs to be confirmed. The biogas plant inflow samples have emitted tentatively more CO_2 and the outflow samples released more CH_4.

1. Introduction

Biochemical processes in nature depend on a channeling of energized electrons (Benckiser, 1997, 2007a). Intra- and extracellularly respiring bacteria use a broad variety of electron acceptors and as electron transport vehicles cytochromes and nanowires (Grainick and Newman, 2007; Rohde et al., 2010). However, the electron channeling through systems is de facto not really understood. The standard redox potentials ($E_o{}'$) describe the conditions under which organic and inorganic components are reduced or oxidized whereby positive $E_o{}'$-values (O_2/H_2O, +818, aerobic respiration; NO_3^-/NO_2^-, +432; NO/N_2O, +1173; N_2O/N_2, +1355 mV, anaerobic respiration) characterize an easy electron shifting toward one of the redox partner, which is then converted to reduced status, and negative $E_o{}'$-values (CO_2/CH_4, −245, anaerobic respiration; organic intermediates/acids, ethanol, −225 to −480 mV, fermentations) indicate that electron shifting occurs only at a high electron pressure.

Sago factory waste waters, released by nearly 1000 sago processing industries in the monsoon governed districts of Salem and Namakkal, Tamil Nadu, South India, are electron surplus

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[1] Now at.

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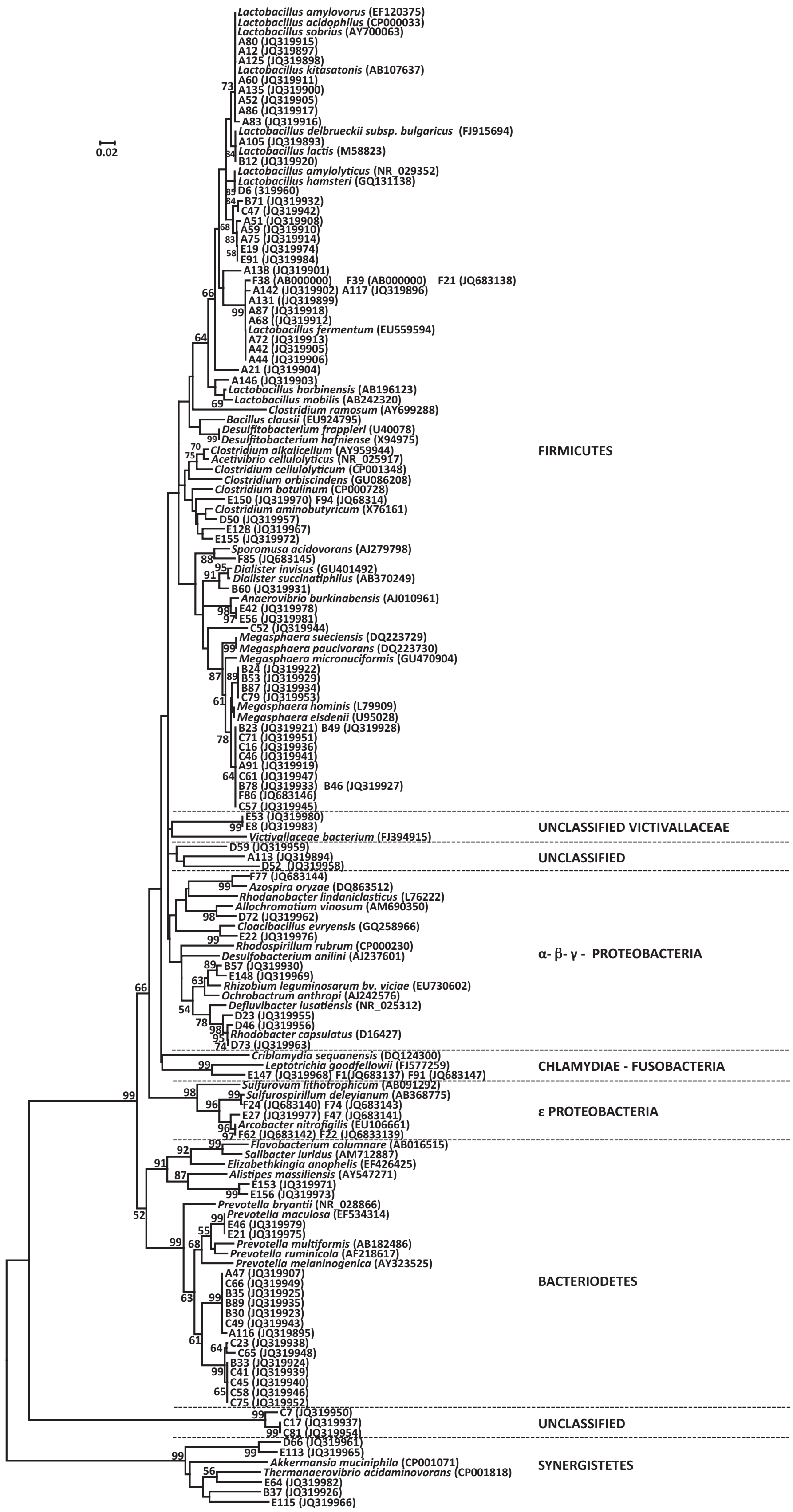

Fig. 1. Phylogenetic tree based on partial 16S rRNA gene library of sago factory effluents (about 450 bp), neighbor-joining with highest similarity and accession numbers in parentheses. Clones designated as A, B, C are from inflows and D, E and F from outflows of small (ARD), medium (SSS) and large scale (VMS) sago industries, respectively during on-season. The percentage of 1000 bootstrap replicates are shown at the left nodes when at least 50%. The scale bar indicates two changes per 100 bp nucleotides.