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BIOLOGICAL CONTROL OF METHANE IN COAL MINES - AN INTERIM REPORT

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BIOLOGICAL CONTROL OF METHANE IN COAL MINES - AN INTERIM REPORT

by

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INTRODUCTION

Most coal mine explosions have been caused by the emission and accumulation of methane. To ensure a safer mining environment and to maintain productivity at the desired level methane control during all phases of mining is considered essential.

A review of techniques developed for dealing with methane in coal mines indicate that control by ventilation alone may not be the answer to all mining situations. Alternative methods such as methane drainage during mining operations or in advance of mining showed promising results [1,2,3].

So far, little attention has been paid to the application of biotechnology for methane control. Attempts were made in Eastern Europe and more recently in India [4] to use methane oxidizing microorganisms for removing methane in coal mines.

A complete review of biological control of methane was recently completed in a CANMET contract [5]. The report also includes a summary of the properties of methane oxidizing microorganisms (MOM). Conclusions from the report can be summarized as follows:

1. Methane oxidizing bacteria have been field tested in at least two countries, Russia and India and the results appear to be encouraging.

2. The physiological properties of methane oxidizing microorganisms were consistent with the conditions found in coal mines. In particular the following parameters were found to be favourable for their use.
   a. Temperature - The temperature optima for most methane oxidizers fall in the range 15°-40°C which is within the range found in most coal mines. For cooler temperature applications, psychrophilic organisms could be isolated and used.
   b. pH - the pH optima for these organizms were found to be between 5.0 and 8.0 which is similar to the pH of most mine waters studied.
   c. Pressure - Pressure effects were not considered to be a factor since a large variety of organisms were shown to be capable of withstanding to high pressures without showing adverse effects.
   d. Ion Effects - Because of the various ionic requirements of the methane oxidizers, organisms would be isolated from waters associated with the particular mine chosen for potential application so that they would be acclimatized to that particular ionic environment.
   e. Oxygen Requirements - The study concluded aerobic organisms require a large supply of oxygen and could not be used for infusion to a coal seam. However, if anaerobic organisms were available they could be used with a suitable electron acceptor e.g. nitrate or sulphate ions. Availability of oxygen should not be a problem for surface applications or for use in ventilated coal storage silos.
   f. Physical Characteristics - Bacteria would be the "organism-of-choice" since their smaller size permits better penetration to the coal mass.

3. Biological oxidation of methane is likely to have applications in the following mining situations:
   a. Hydraulic Mining - The organisms could be added to the cutting fluids during production and/or transportation of coal.
   b. Surface Application - The organisms could be sprayed on the rib, roof and other accessible areas in a coal mine.

c. Storage and Transportation Systems - Organisms could be sprayed onto coal during storage and transportation provided oxygen supply is adequate to maintain the bacterial activity.

d. In cases where temperatures are low either psychrophilic organisms could be used or heated biological scrubbing towers could be tried.

OBJECTIVES

The first phase of the research program was directed to the following objectives:

1. To isolate methane oxidizing organisms from samples collected from operating coal mines.
2. To maximize the methane oxidizing activity under simulated mine conditions.
3. To carry out static and dynamic testing of the organisms in a laboratory model.

If the results prove encouraging, tests with larger amount of coal (2-3 tons) will be carried out in the laboratory before actual trial is contemplated in a coal mine.

EXPERIMENTAL

Coal and water samples were obtained from a mine in South Eastern British Columbia working a low volatile bituminous coal seam which is low in sulphur (0.3-0.4%) and contains medium to high levels of methane. Methane oxidizing bacteria could be isolated from all the samples but much higher levels of organisms were isolated from the water samples than from the coal samples.

All methane utilizing bacteria isolated were pigmented (pink to salmon). Two major types were present on mineral agar plates incubated in a methane atmosphere, one culture consisted of micro colonies resembling

Methylomonas methano-oxidans and the other resembling M. methanica. On continual transfer in liquid culture a stable population evolved which gavesalmon coloured colonies on mineral agar. The organisms could only be grown at pH between 6.0 and 7.5 with an optimum at 7.0.

Large quantities of the methane oxidizing bacteria were grown in stirred flasks containing mineral salts medium (Bushnell Haas) in an atmosphere of 20% methane, 80% air. The cells were harvested by centrifugation and were added (5 mls of a concentrated cell suspension) to flasks containing 200 g of the low volatile bituminous coal and 20 mls of Bushnell Haas medium. The flasks were sealed and the atmosphere was made to 12% methane. After incubation at 30°-33°C overnight the methane concentration was reduced to 1-2%. The above cycle was repeated a number of times to ascertain the time period the bacteria would remain active. The results of this experiment are illustrated in Figure 1. The organisms were just as active after 36 cycles (in a 50 day period) as they were at the start. Figure 2 illustrates the kinetics of one such cycle.

The above experiments were repeated with a high sulphur coal (5.1%). Preliminary experiments showed that the bacteria were not active in such cases since there was a rapid drop in the pH of the medium to approximately 5.0 presumably caused by the oxidation of the sulphur present in the coal.

A dynamic test rig was assembled and filled with low volatile bituminous coal and microbial cells added. An atmosphere of 13% methane was passed through this rig at flow rates of 0.5, 1.0 and 2.0 volumes/day. Methane concentrations were reduced by 72, 65 and 39% respectively.

Lastly, an experiment was conducted to mimic the situation in a coal silo. When bacterial cells were added to freshly ground coal in sealed containers no methane was observed after 7 days. The methane concentration in the container where no bacteria were added reached 6.0%. This is well illustrated in Figure 3.

CONCLUSION

Methane oxidizing bacteria were successfully isolated from coal mine samples which can be grown easily under controlled conditions. These organisms were found to be active during oxidation of methane when added to samples of low sulphur, low volatile bituminous coal. They were not active when added to high sulphur coal.

The rates of methane oxidation observed were significant and the method appears to have the potential to be applied on a large scale. Further work is now in progress and a detailed report is expected towards the end of this year.

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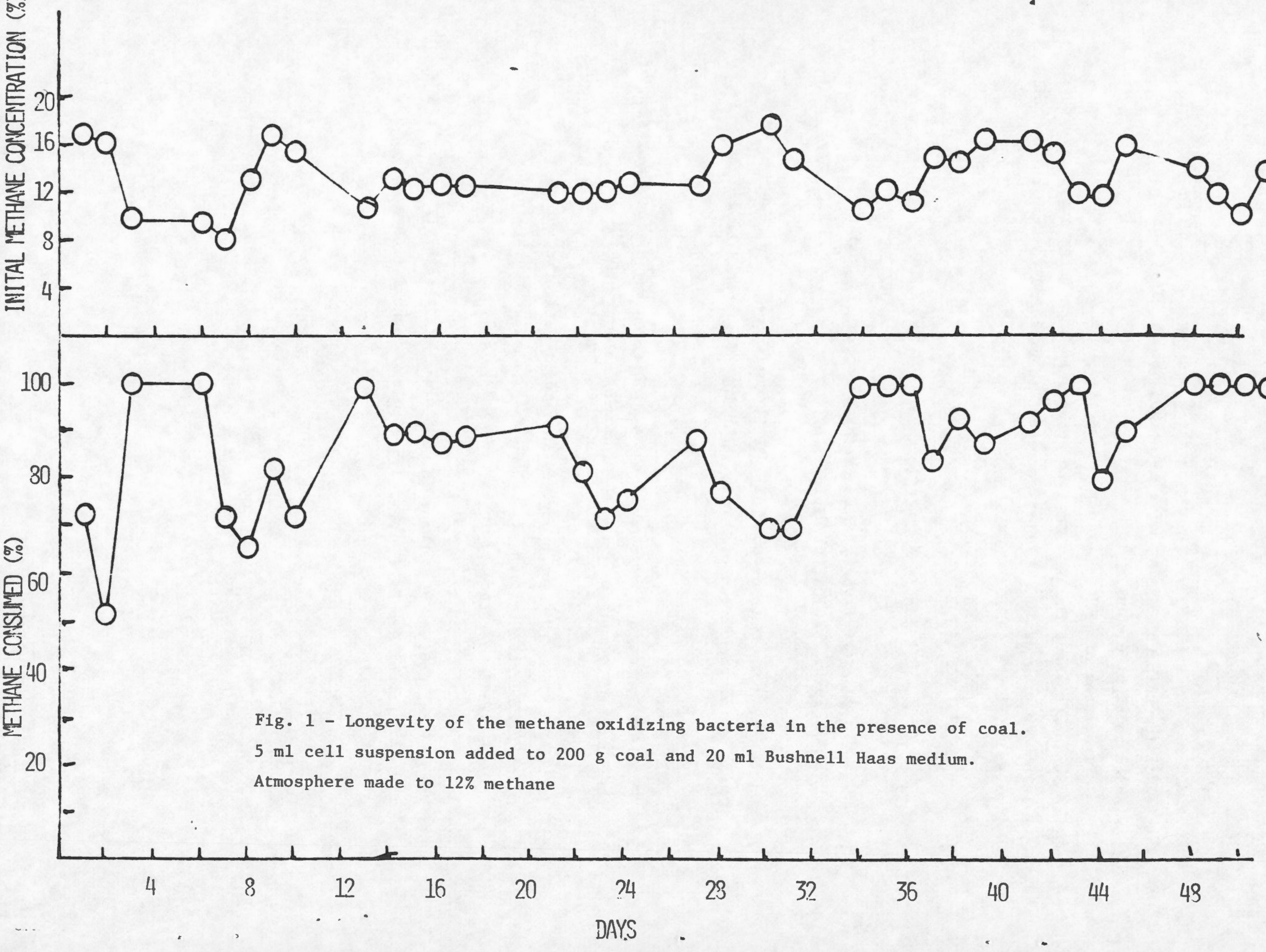
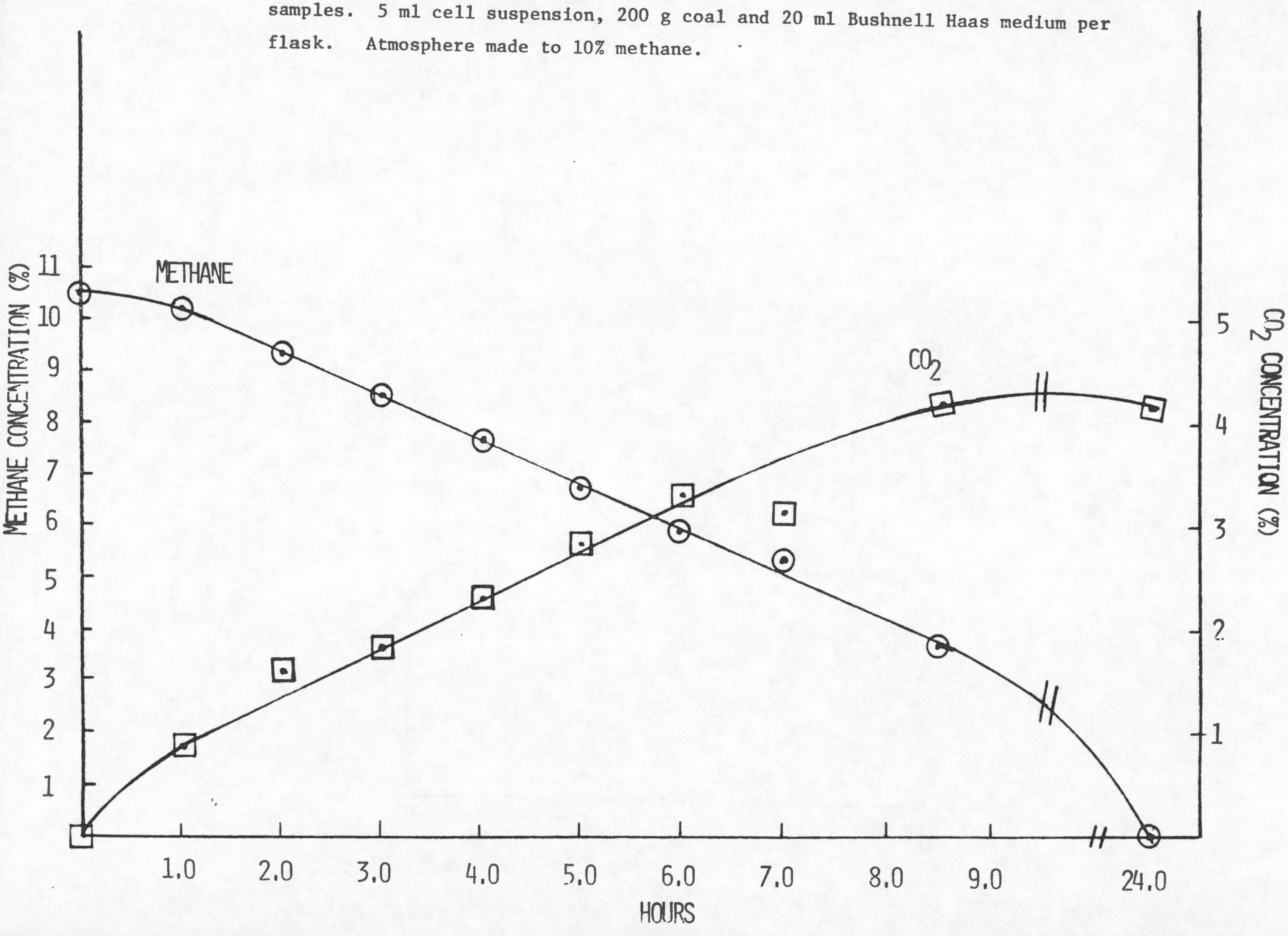


Fig. 1 - Longevity of the methane oxidizing bacteria in the presence of coal. 5 ml cell suspension added to 200 g coal and 20 ml Bushnell Haas medium. Atmosphere made to 12% methane

Fig. 2 - Rate of disappearance of methane by methane oxidzing bacteria in coal samples. 5 ml cell suspension, 200 g coal and 20 ml Bushnell Haas medium per flask. Atmosphere made to 10% methane.



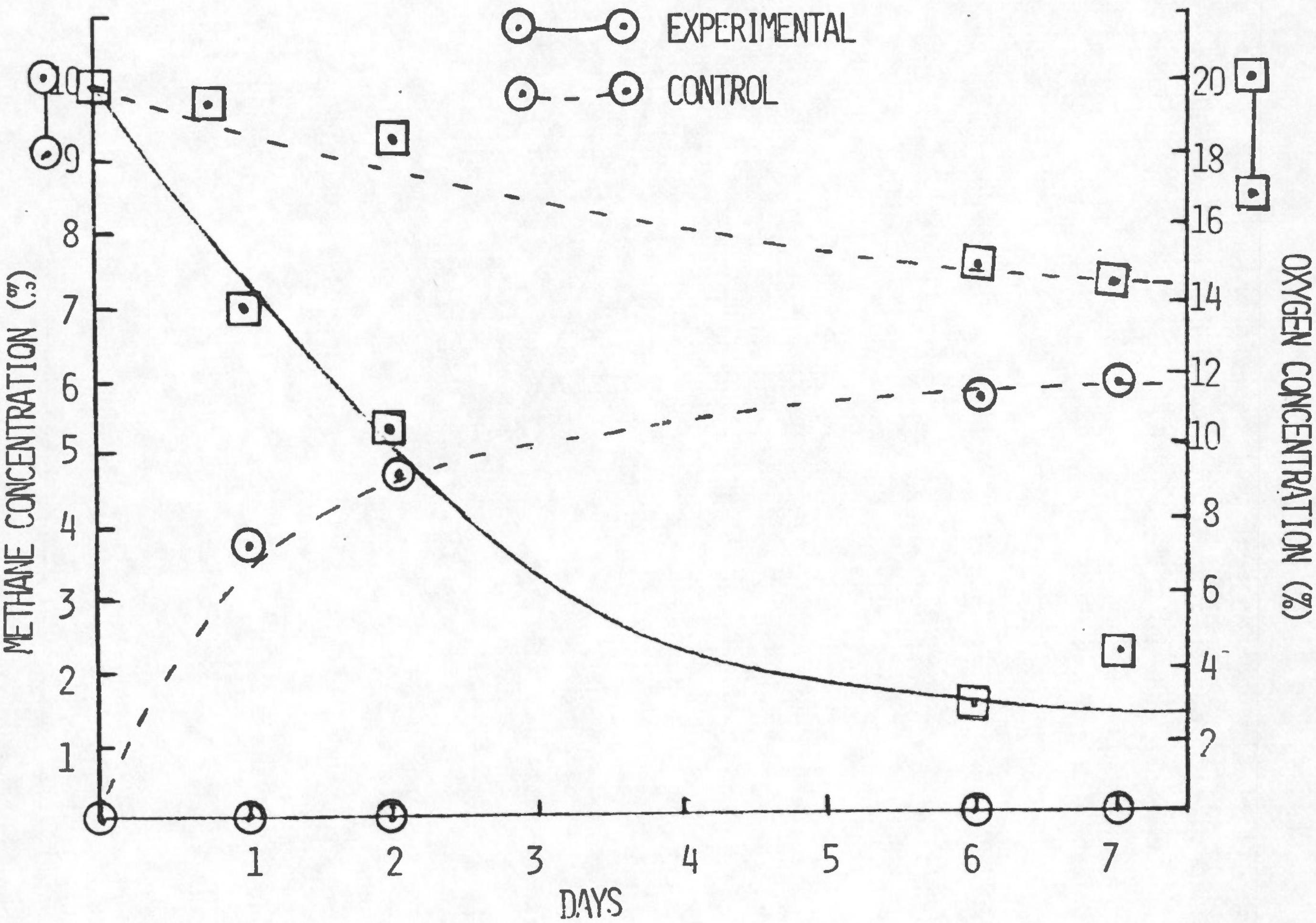


Fig. 3 - Control of methane concentration in a model coal silo. 5 ml cell suspension, 20 ml Bushnell Haas medium, added to 200 g freshly ground coal in a sealed flask.