CONF-780665--1

IODINE-HYDROGEN PEROXIDE AS A DISINFECTANT FOR FUEL STORAGE BASIN WATER

by

D. W. Rhodes

ALLIED CHEMICAL CORPORATION
IDAHO OPERATIONS PROGRAM - OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CIO-4600

A paper for presentation at the
33rd Northwest Regional Meeting of
The American Chemical Society

Seattle, Washington

June 14-16, 1978

Prepared for
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
IDAHO OPERATIONS OFFICE
UNDER CONTRACT EY-76-C-07-1540

MASTER

ENB

IODINE-HYDROGEN PEROXIDE AS A DISINFECTANT FOR FUEL STORAGE BASIN WATER

I. INTRODUCTION

The Fuel Storage Basin at the Idaho Chemical Processing Plant (ICPP) consists of three large basins interconnected by a transfer canal. These basins contain a total volume of about 1.5×10^6 gallons of raw water. The water is recirculated through a filter with part of the discharge stream going through columns containing Zeolon-900 and Amberlite-200 ion exchangers to remove radioactive cesium and strontium. The fuel storage basin is operated basically as a closed system. The only water leaving the basin consists of small volumes that are processed in the plant evaporator or water lost by surface evaporation. The makeup water is raw water that is used to rinse casks as they are being removed from the basin.

To identify and handle fuel elements stored approximately 20 ft under water, good water clarity is mandatory. A low population of microorganisms is an essential part of maintaining good water clarity. To inhibit the growth of mocroorganisms for the past two years, iodine has been used as a bacteriacide. The iodine converts rapidly to iodide[1] under the existing water conditions, and calcium hypochlorite is added periodically to oxidize the iodide back to iodine. Although calcium hypochlorite is itself a bacteriacide, the amount added is too small to inhibit the growth of microorganisms adequately. In addition, the chlorine produced is converted rapidly to chloride, which is not a bacteriacide.

The use of chlorine has resulted in a buildup in the concentration of chloride, which is potentially corrosive to aluminum fuel elements

stored in the basin water. Recently, a reverse osmosis unit coupled with an auger type evaporator has been operated to reduce the concentration of chloride and other salts in the water. To prevent another buildup of chloride, the use of calcium hypochlorite must be discontinued.

This report describes the use of hydrogen peroxide to oxidize iodide to iodine in fuel storage basin water. Measurements of the microorganism population as well as residual iodine concentrations were used as the criteria for effectiveness.

II. BASIN WATER

The chemical composition of the basin water is shown in Table I.

TABLE I

CHEMICAL COMPOSITION OF ICPP FUEL STORAGE BASIN WATER
(April 1978)

Chemical	Concentration (mg/L)
Sodium	503
Calcium	11
Magnesium	2
Nitrate	562
Chloride	320
Bicarbonate	118
Sulfate	31
Total Dissolved Solids	1480
pH	8.4

In addition to the chemicals shown in Table I, the water contains approximately 0.01 μCi/ml of radionuclides, primarily Cs-137 and Sr-90. The floor of the basin was covered with sludge consisting primarily of the oxides of iron and silicon representing corrosion products and wind blown sediments that have accumulated over the years. Most of this sludge has been removed recently by a vacuuming process.

III. EXPERIMENTAL PROCEDURE

Steel drums were filled with about 50 gal of water from the fuel storage basin. The water was then seeded with a bacteria culture that had been grown in a culture broth. The broth had been seeded with bacteria colonies obtained from routine monitoring of the basin water by the plate technique. One drum was used as a control, one was treated with iodine, and periodically, calcium hypochlorite. Two other drums were treated with iodine and hydrogen peroxide; the water in one drum was controlled at pH 8.2 and the other at pH 6.0. The water at the start of the iodine tests contained 2 ppm of iodide that had been added as sodium iodide.

Samples of water were removed periodically and analyzed for iodine by the colorimetric method and for bacteria by the plate culture method. The results of these tests are shown in Figures 1-4.

IV. EXPERIMENTAL RESULTS

The curves shown in Figure 1 and 2 depict the results of the tests with basin water at pH 8.2. The results indicate that two additions of calcium hypochlorite (HTH) to the iodine containing water succeeded in reducing the microbiological population significantly. Whether this was due

only to the iodine formed (Figure 2) or partly due to the hypochlorite itself could not be determined. The initial addition of 10 ppm H_2O_2 was not effective in reducing the microbiological population nor in producing more than about 0.4 ppm I_2. By the time the third addition had been made (total of 30 ppm H_2O_2), however; the bacterial count was decreasing significantly and the I_2 concentration had increased to about 1 ppm. The initial addition of 30 ppm H_2O_2 produced a noticeable reduction in the bacterial population after about 5 days; the iodine concentration remained at 1 ppm or higher during the 14 day test. The relatively high pH of 8.2 reduces the effectiveness of the H_2O_2 in oxidizing the iodide. Note that the iodine concentration decreased rapidly soon after the addition of the HTH, but persisted for several days in the presence of H_2O_2.

The curves shown in figures 3 and 4 depict the results of the tests in the basin water at pH 6.0. The H_2O_2 is more effective in oxidizing the iodide at pH 6 than at pH 8.2 according to the equation:[2]

$$H_2O_2 + 2I^- + 2H^+ = I_2 + 2H_2O$$

In Figure 3, the bacterial population decreased rapidly for all treatments. According to the results in Figure 4, this occurred because the iodine concentration remained at 0.8 ppm or greater for all three levels of H_2O_2 added (10, 20, 30 ppm). Even after 90 days there were still significant amounts of I_2 in the water even though no additional H_2O_2 had been added.

V. APPLICATION

A system to add H_2O_2 to the fuel storage basin water at the ICPP will be installed in the near future. The iodine, which is added only infrequently (once or twice a year) will be added either as NaI broadcast by hand or as I_2 using an iodinator that is already available.

VI. CONCLUSIONS

Based on the results of the pilot-scale tests, a small concentration of hydrogen peroxide will oxidize iodide to iodine in basin water and maintain an iodine residual for several days. Bacteria control is adequate under these conditions, and the buildup of chloride, which occurred when chlorine was used as a bacteriacide, is avoided.

VII. REFERENCES

1. Wilding, Malcolm W., Iodine to Control Microbiological Growth in Fuel Storage Basin Water, ICP-1109 (February 1977).

2. Kolthoff, I. M., and E. B. Sandell, Textbook of Quantitative Inorganic Analysis, The MacMillan Co., New York, N.Y. 1947.

Figure 1

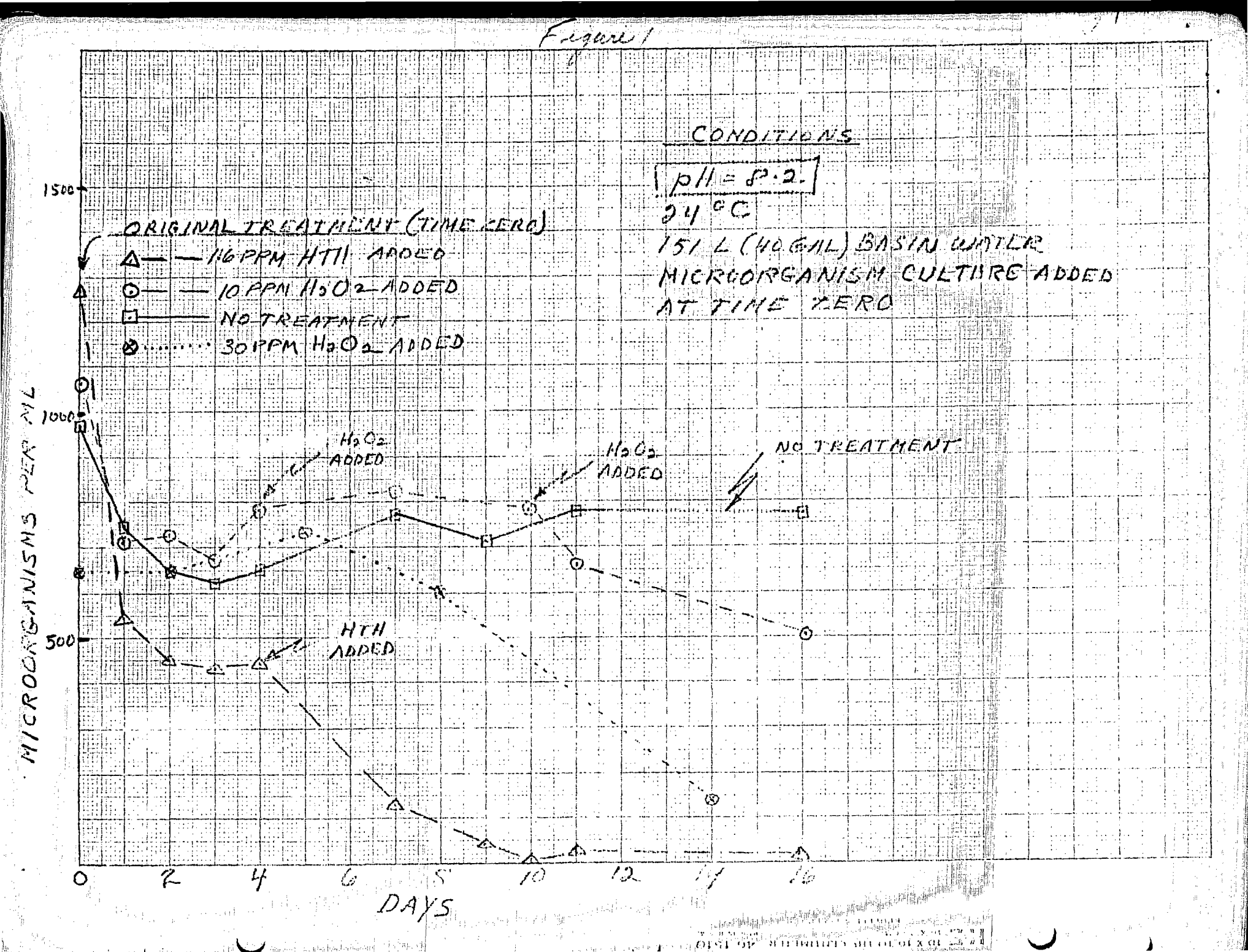

CONDITIONS
pH = 8.2
24 °C
151 L (40 GAL) BASIN WATER
MICROORGANISM CULTURE ADDED
AT TIME ZERO
ORIGINAL TREATMENT (TIME ZERO)
16 PPM HTH ADDED
10 PPM H2O2 ADDED
NO TREATMENT
30 PPM H2O2 ADDED
1500
1000
500
1
MICROORGANISMS PER ML
H2O2 ADDED
H2O2 ADDED
NO TREATMENT
HTH ADDED
0
2
4
6
8
10
12
14
16
DAYS

Figure 2

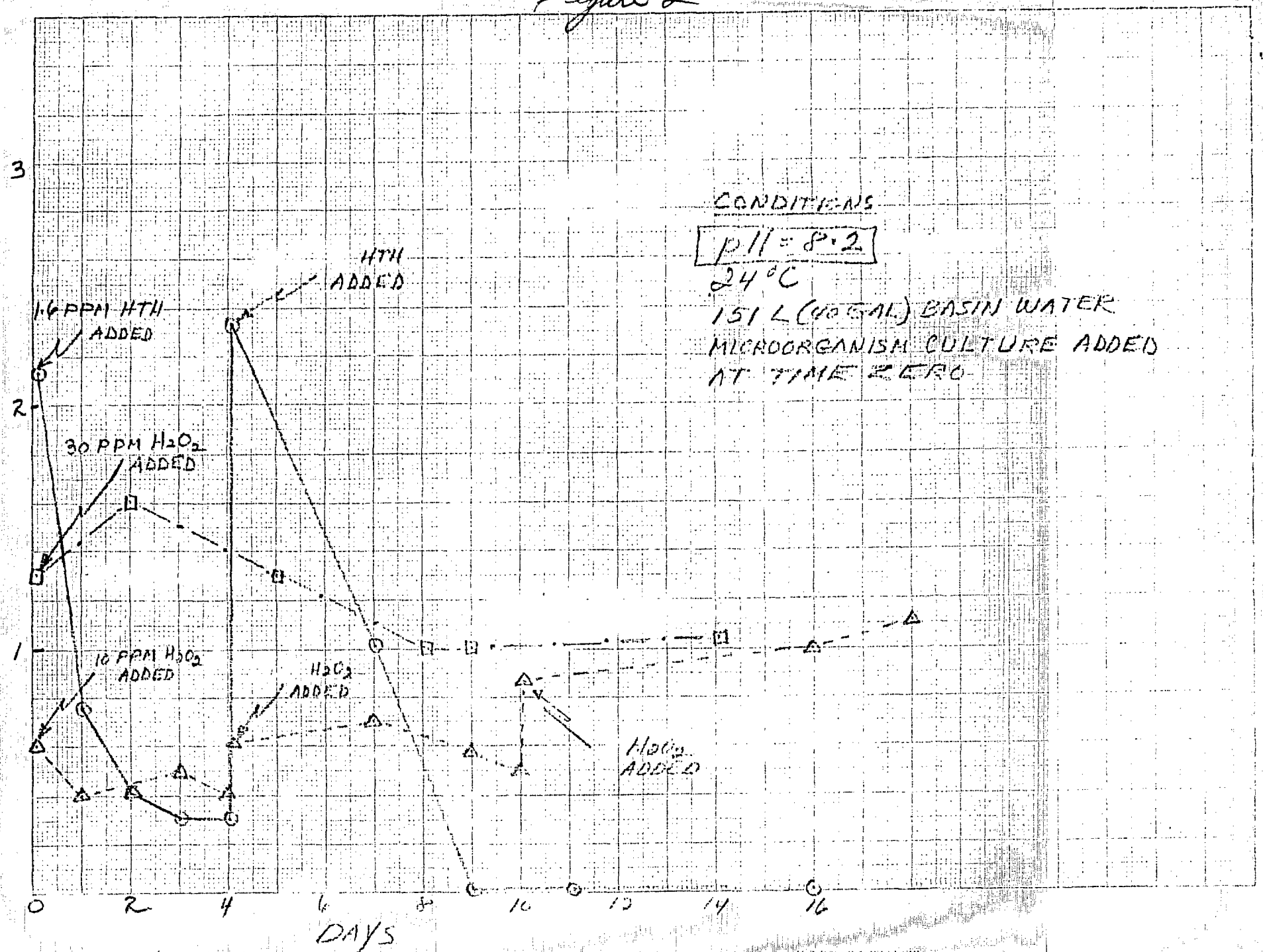

CONDITIONS
pH = 8.2
24 °C
151 L (40 GAL) BASIN WATER
MICROORGANISM CULTURE ADDED
AT TIME ZERO
1.6 PPM HTH ADDED
HTH ADDED
30 PPM H_2O_2 ADDED
10 PPM H_2O_2 ADDED
H_2O_2 ADDED
H_2O_2 ADDED
PPM CHLORINE
DAYS
0
2
4
6
8
10
12
14
16
1
2
3

Figure 3

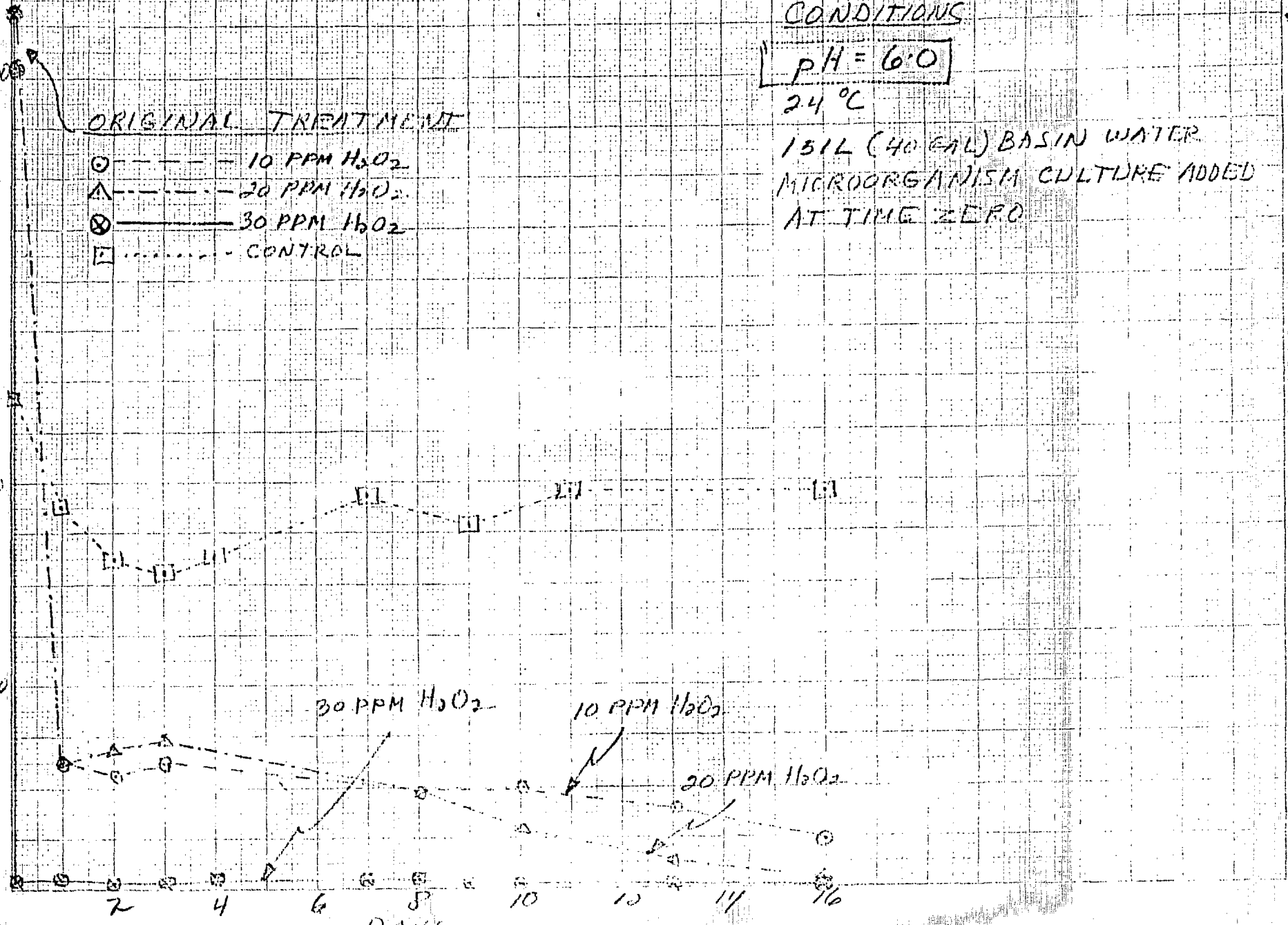
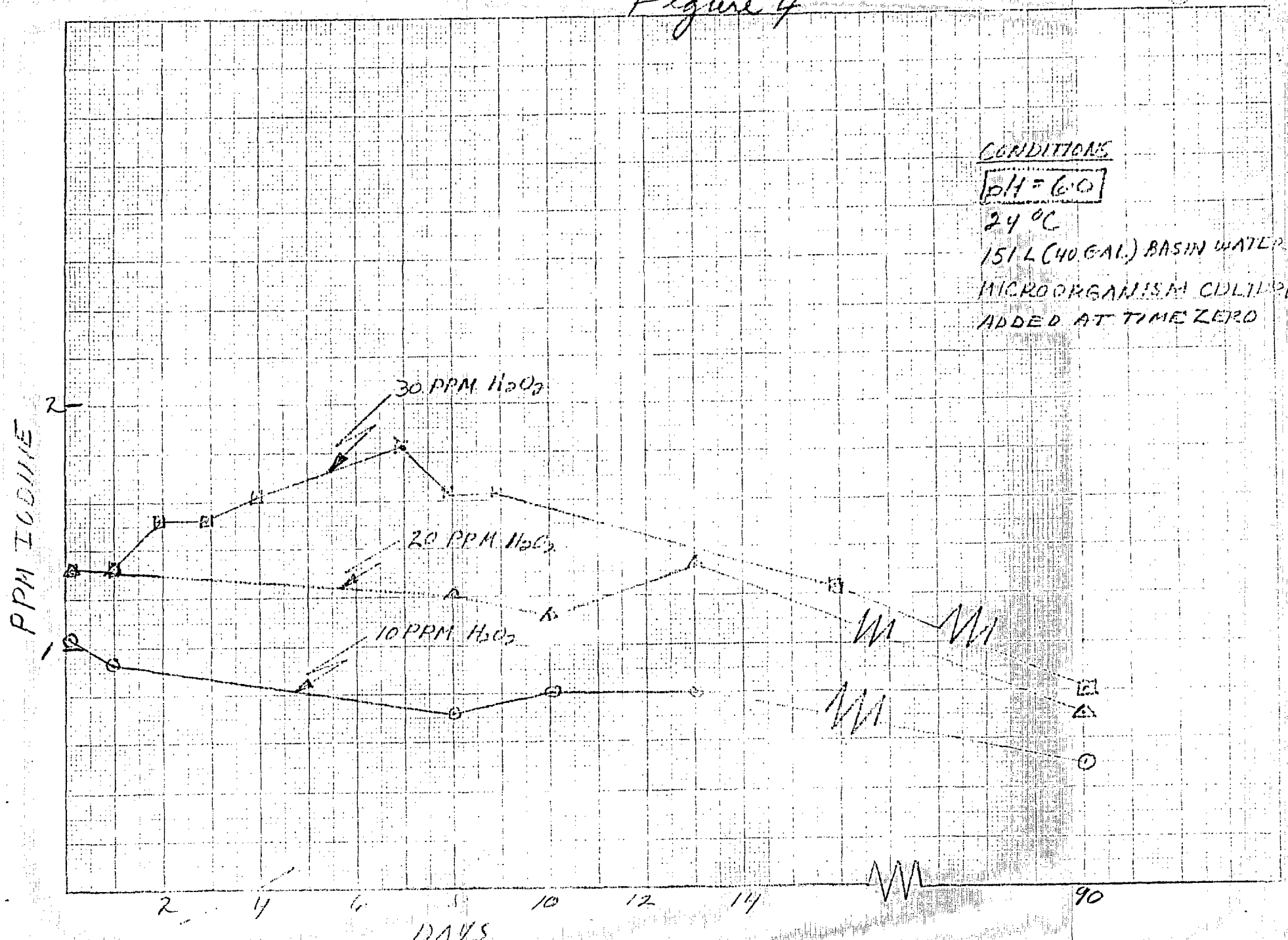

CONDITIONS
pH = 6.0
24 °C
151 L (40 GAL) BASIN WATER
MICROORGANISM CULTURE ADDED
AT TIME = ZERO
ORIGINAL TREATMENT
10 PPM H_2O_2
20 PPM H_2O_2
30 PPM H_2O_2
CONTROL
MICROORGANISMS / ml
1500
1000
500
30 PPM H_2O_2
10 PPM H_2O_2
20 PPM H_2O_2
2
4
6
8
10
13
14
16
DAYS

Figure 4


CONDITIONS
pH = 6.0
24 °C
151 L (40 GAL.) BASIN WATER
MICROORGANISM CULTURE
ADDED AT TIME ZERO
30 PPM H_2O_2
20 PPM H_2O_2
10 PPM H_2O_2
PPM IODINE
DAYS
2
1
2
4
6
8
10
12
14
90