GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

# PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. E-20-C01 — DATE 5/20/82

Project Director: Dr. E.S.K. Chian — School/Lab Civil Engr.

Sponsor: AMAF Industries, Incorporated

Type Agreement: Contract No. AMAF-R12-002 (under DOE Prime No. DE-AC01-82NE-31501)

Award Period: From 12/1/82 To 1/31/83 (Performance) 1/31/83 * (Reports)

Sponsor Amount: $188,546 (incrementally funded at $50,255 through 3/31/82) Contracted through:

Cost Sharing: none — GTRI/GIT

Title: Investigation of Containment of Co-disposal of Low-Level Radioactive Waste Landfills

## ADMINISTRATIVE DATA

OCA Contact Faith G. Costello

1) Sponsor Technical Contact:

Same as 2)

2) Sponsor Admin/Contractual Matters:

Mr. Alfred G. Meyer, Manager
Contracts and Procurement (C&P)
AMAF INDUSTRIES, Incorporated
103 Sterrett Building
P.O. Box 1100
Columbia, Maryland 21044
(301) 995-1919

Defense Priority Rating: NA — Security Classification: NA

## RESTRICTIONS

See Attached (DOE) Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with AMAF

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MAY 1982
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SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 6/28/85

Project No. | School/~~Lab~~ CE

GTRC / ~~GIT~~

Title: ... Within Sanitary Landfills

Effective ... (Performance) 11/7/84 (Reports)

Continued by Project No. N/A

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Chian --

Co-disposal
of
low
level
radioactive
waste...

2-N-T+B

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E-20-C01
( old E-20-656 )

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CIVIL ENGINEERING

TELEPHONE:
(404) 894-2265

March 12, 1982

Dr. Robert M. Dixon
Director, IRDEN
Suite 500/The Grant Building
44 Broad Street, N.W.
Atlanta, Georgia 30303

Re: Research on "Co-Disposal of Low-Level Radioactive Waste with Sanitary Landfill," Contract number AMAF-R12-002

Dear Dr. Dixon:

This letter summarizes the work performed during the period from December 1, 1981 through January 31, 1982. The major efforts have been directed toward monitoring of the final stage of leachate recirculation study with the two bench-scale simulated landfills, and preparation for the closure of the systems. The progress of these efforts are given in the following:

I. Monitoring of bench-scale simulated landfills

As can be seen in Table 1, the work performed during this period of study (i.e., from 12/1/81 through 2/1/82) corresponds to day 197 through day 259 of operation. Continuing monitoring of these systems was conducted to thoroughly evaluate the effect of leachate recycle on the fixation of radionuclides in the bench-scale landfill systems. The parameters monitored during this period included COD, $BOD_5$, TOC, etc. in leachates along with specific analyses of radioactivities of Co-58, Cs-134, Sr-85 and H-3 and other metals such as iron, manganese, etc. The cumulative amount of gas produced was also monitored. They are given in detail in the following:

a) Gross parameters of leachates

It is seen from Figures 1, 2 and 5, that the profiles of COD, $BOD_5$, and TOC removed can be superimposed. The rapid removal of these parameters corresponds quite well to the changes of pH in leachates (Figure 7) during the same periods (day 60 through 100 for the control unit and day 118 through 145 for the recycle unit). The changes in pH, in turn, corresponds to the decrease of total volatile acid as shown in Figure 6. The removal of volatile acid is again confirmed by the decrease in ORP (Figure 9) as the methane formers prevail under more reduced conditions. In general, the decrease in alkalinity (Figure 8) also follows hand in hand the reduction of volatile acids (Figure 6).

Whereas the ORP tends to increase gradually (Figure 9), reflecting a decreased rate of methane production, the other parameters such as COD, (Figure 1), $BOD_5$ (Figure 2), TOC (Figure 5), volatile acid (Figure 6), and pH (Figure 7) become levelling off or disappeared (Figure 6) after day 140. This situation lasts until day 252. At this point (i.e., day 252), it was felt that both the control and the recycle units were well stabilized. A decision was then made to discontinue the study four weeks later (i.e., two weeks after day 266, Table 1).

b) Corrections for $BOD_5$ in leachates.

Due to the continuing removal of leachate samples for analysis, the amount of $BOD_5$ in leachate should be corrected based on a mass balance or concentration of a conservative constituents in leachate. Figure 4 shows the correction factors for $BOD_5$ based on the concentration of the conservative ion chloride ($Cl^-$) in leachates and on the mass balance of chloride. The corrected values of BOD are shown in Figure 3. The merit of leachate recycle can be seen clearly after correcting for leachate volumes (Figure 3). The use of a semilog-log paper tends to expand the $BOD_5$ scale at lower concentration ranges thus enhances comparisons of their relative values (Figure 3).

c) Activity of radionuclides in leachates

As can be seen in Figure 11, Co-58 is removed from leachates to a very low level after 78 days of operation with the control and 128 days with the recycle units. However, after corrections for leachate volumes were made, the radioactivity of Co-58, as plotted on an expanded scale at the low activity ranges (Figure 12), shows a slight increase in leachate from the recycle unit. This may have been caused by resolubilization of Cobalt sulfide through complexation with the reflectory organic compounds, e.g., humic substances, which tends to build up during a prolonged period of operation (Chian and DeWalle, 1977). The formation of metal sulfides in leachates can be seen clearly in Figure 13. Figure 12 shows that a rapid reduction in radioactivity of Co-58 corresponds to a rapid drop in concentration of sulfide in leachates (Figure 13).

The advantage of leachate recycle in the fixation of radioactivities of Sr-85 and Cs-134 in the simulated landfills is demonstrated clearly after corrections for leachate volumes were made (Figure 12). It is seen in Figure 12 that a two-and-half-fold reduction in radioactivities of Sr-85 and Cs-134 was accomplished with leachate recycle. However, the mechanisms behind the reduction of activity of radionuclides Sr-85 and Cs-134 are unknown. Efforts will be made in the coming year to interpret results of this study.

d) Analysis of selected metal ions in leachate

It is seen in Figure 14 and 16, the concentrations of both iron and manganese reduced to a steady-state low level after 150 days of operation. In the meantime the concentration of calcium (Figure 15), magnesium (Figure 16), sodium (Figure 16) and potassium (Figure 14) all tend to decrease at a much slower rate after 150 days of operation. The results of metal ion concentrations, together with other parameters such as COD, $BOD_5$, TOC and gas production, will be used later to determine whether these units are stabilized to a point to warrant termination of this study.

e) Gas Production

The gas production and its composition reflect the relative biological activity within the landfills. The cumulative amount of gas produced and the normalized gas composition, based on $CO_2$ and $CH_4$ are shown in Figure 17 and 18, respectively. The amount of gas produced from the recycle unit increases slowly in the first 120 days, and then rapidly afterwards, whereas that from the control unit increases slowly. Based on the amount of gas produced from the two units, it can be concluded that the recycle unit had more rapidly and completely stabilized organic constituents than the control unit. These results confirm the earlier observation of Pohland (1980).

After a rapid increase of gas production from the recycle unit, the cumulative amount of gas produced from both the control and the recycle units follows a somewhat similar rate of increase (Figure 17). This implies that a continuing operation in leachate recycle mode will not accelerate the rate of gas production. In the meantime the normalized gas composition of both units levels off after 120 days of operation (Figure 18).

II. Closure of the bench-scale units

Based on the analysis of the aforementioned results, it can be concluded that both the control and the recycle units are stabilized to a steady-state condition. Also the removal of Co-58 is close to complete. It was felt that further operation of these units would result in a state of diminishing return on research efforts. As such it was decided closure of these units be made after the last samples were taken on day 266 (see Table 1).

These two units were dismantled two weeks after the last samples were taken. All of the contaminated radioactive refuse were packed in drums and shipped to Georgia Tech radioactive safety office for disposal. An acid leaching of the PVC pipe systems showed radioactivities present in the acid water leachate. As such the piping systems cannot be used for non-radioactive studies in the immediate future.

III. Future Research

Future efforts will be directed toward design of two pilot-scale (7500 gal each) simulated landfills and operation of these systems. All safety precautions will be included in the operation of the system outdoors. The final design and operation of these systems will be submitted to the Radioactive Safety Committee of Georgia Tech for approval.

If you have any questions regarding this letter report, please feel free to call me anytime at 894-2265.

Sincerely,

Edward S. K. Chian
Professor of Environmental Engineering

ESKC:pc

cc Dr. F. G. Pohland    Dr. L. Roland    Mr. K. C. Chang
Dr. B. Kahn    Dr. W. Cross    Mr. S. B. Ghosh

| Sampling Date | Time Since Leachate Generation Began, days |
|---|---|
| 5/18/81 | 0 |
| 5/25/81 | 7 |
| 6/1/81 | 14 |
| 6/9/81 | 22 |
| 6/16/81 | 29 |
| 6/22/81 | 35 |
| 6/29/81 | 42 |
| 7/6/81 | 49 |
| 7/13/81 | 56 |
| 7/20/81 | 63 |
| 7/27/81 | 70 |
| 8/3/81 | 77 |
| 8/10/81 | 84 |
| 8/17/81 | 91 |
| 8/24/81 | 98 |
| 8/31/81 | 105 |
| 9/9/81 | 114 |
| 9/14/81 | 119 |
| 9/21/81 | 126 |
| 9/28/81 | 133 |
| 10/5/81 | 140 |
| 10/12/81 | 147 |
| 10/19/81 | 154 |
| 10/26/81 | 161 |
| 11/2/81 | 168 |
| 11/9/81 | 175 |
| 11/16/81 | 182 |
| 11/23/81 | 189 |
| 11/30/81 | 196 |
| 12/7/81 | 203 |
| 12/14/81 | 210 |
| 12/21/81 | 217 |
| 12/28/81 | 224 |
| 1/4/82 | 231 |
| 1/11/82 | 238 |
| 1/18/82 | 245 |
| 1/25/82 | 252 |
| 2/1/82 | 259 |
| 2/8/82 | 266 |

Table 1 The corresponding calender ~~date~~ since initiation of leachate generation

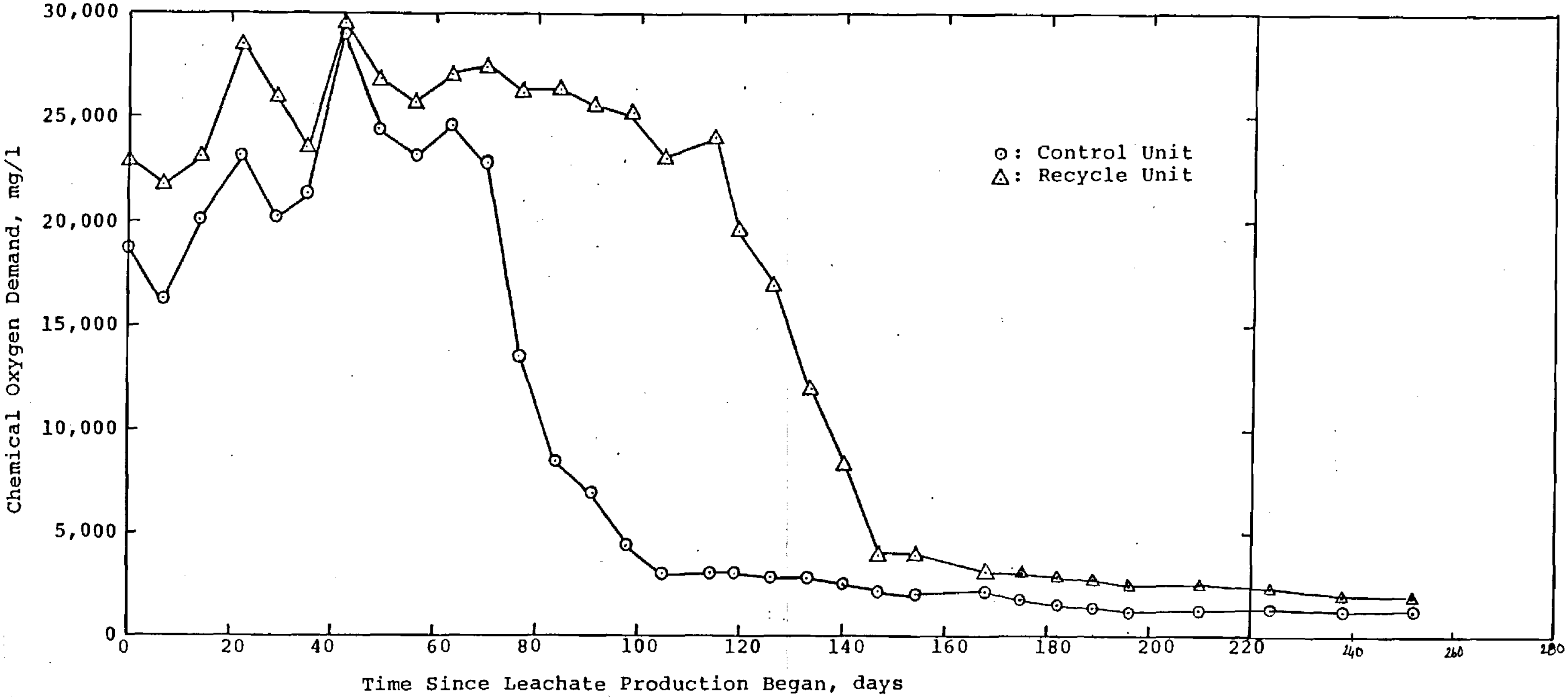
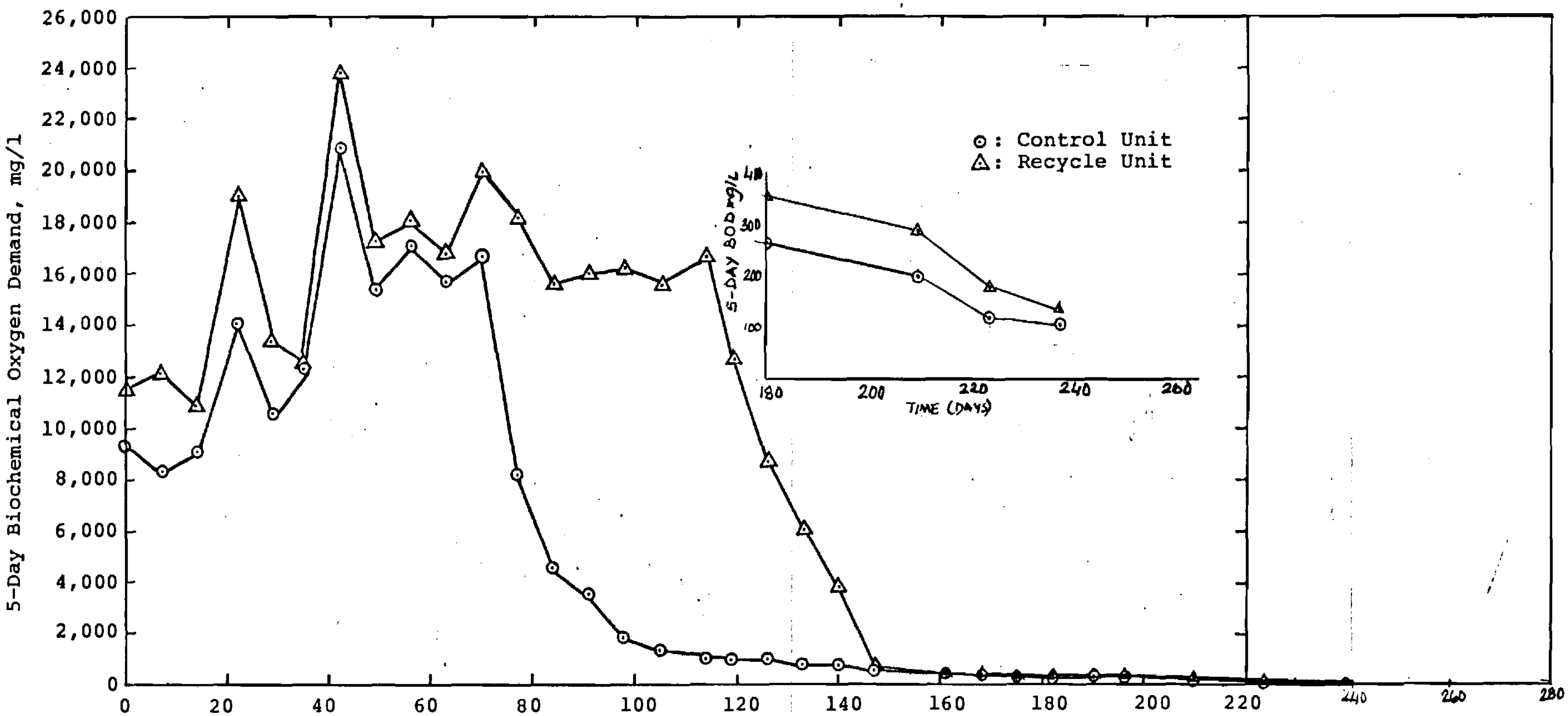



Figure 1. Chemical Oxygen Demand of Leachate




Time Since Leachate Production Began, days

Figure 2. 5-Day Biochemical Oxygen Demand of Leachate

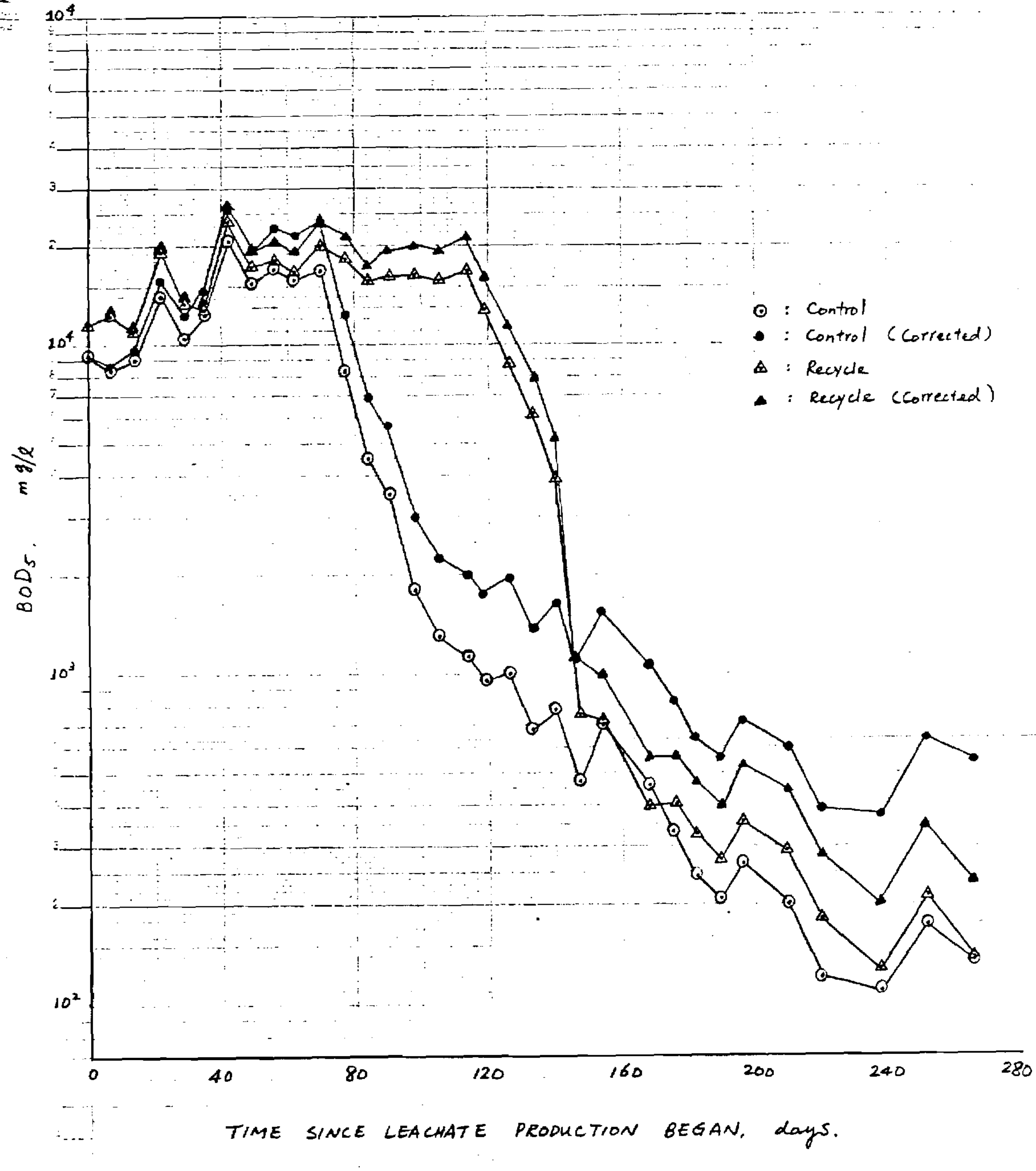



Figure 3.

Semi-Logarithmic
4 Cycles x 10 to the inch

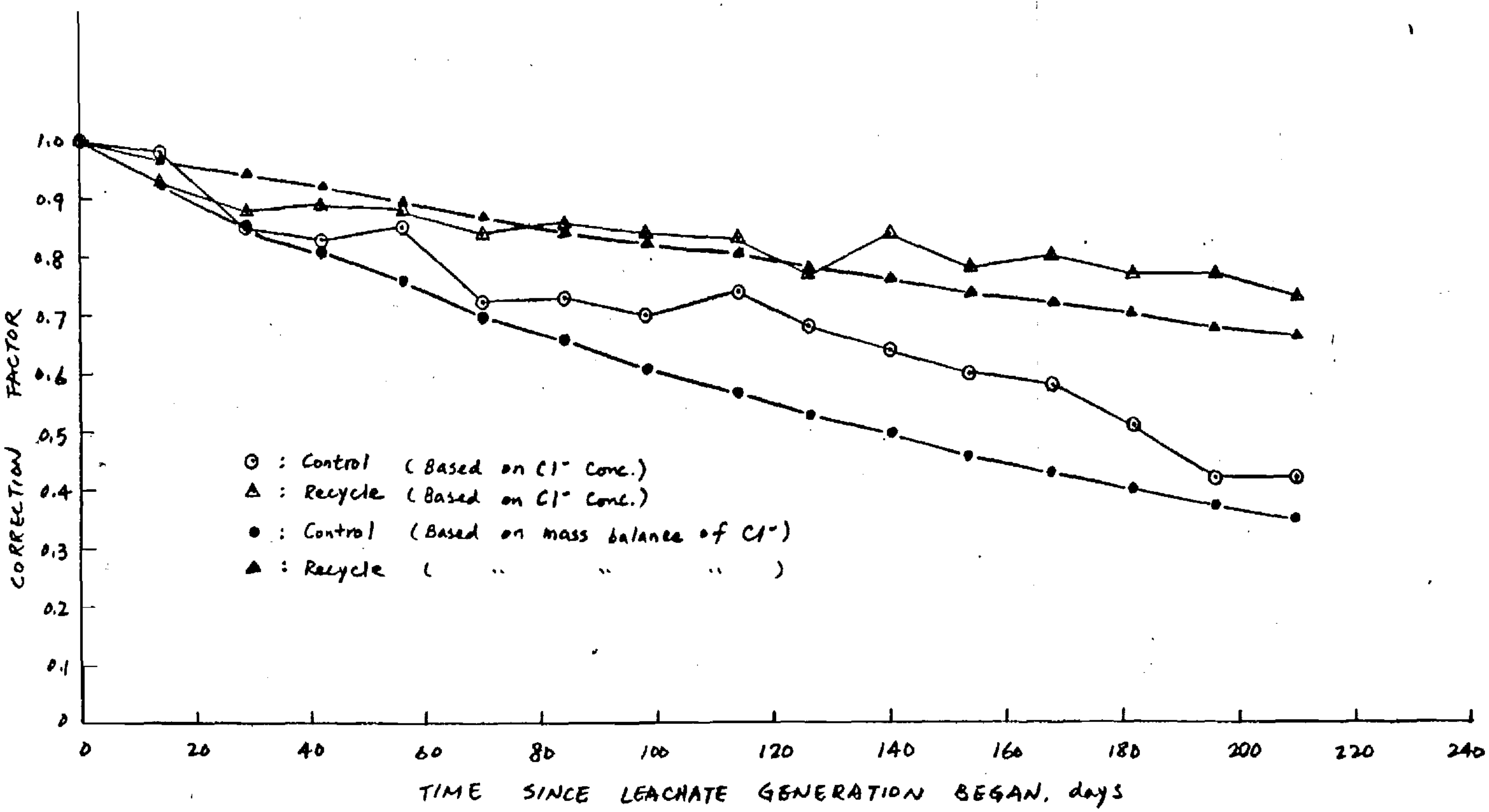



FIGURE 4: CORRECTION FACTORS OF THE SYSTEM

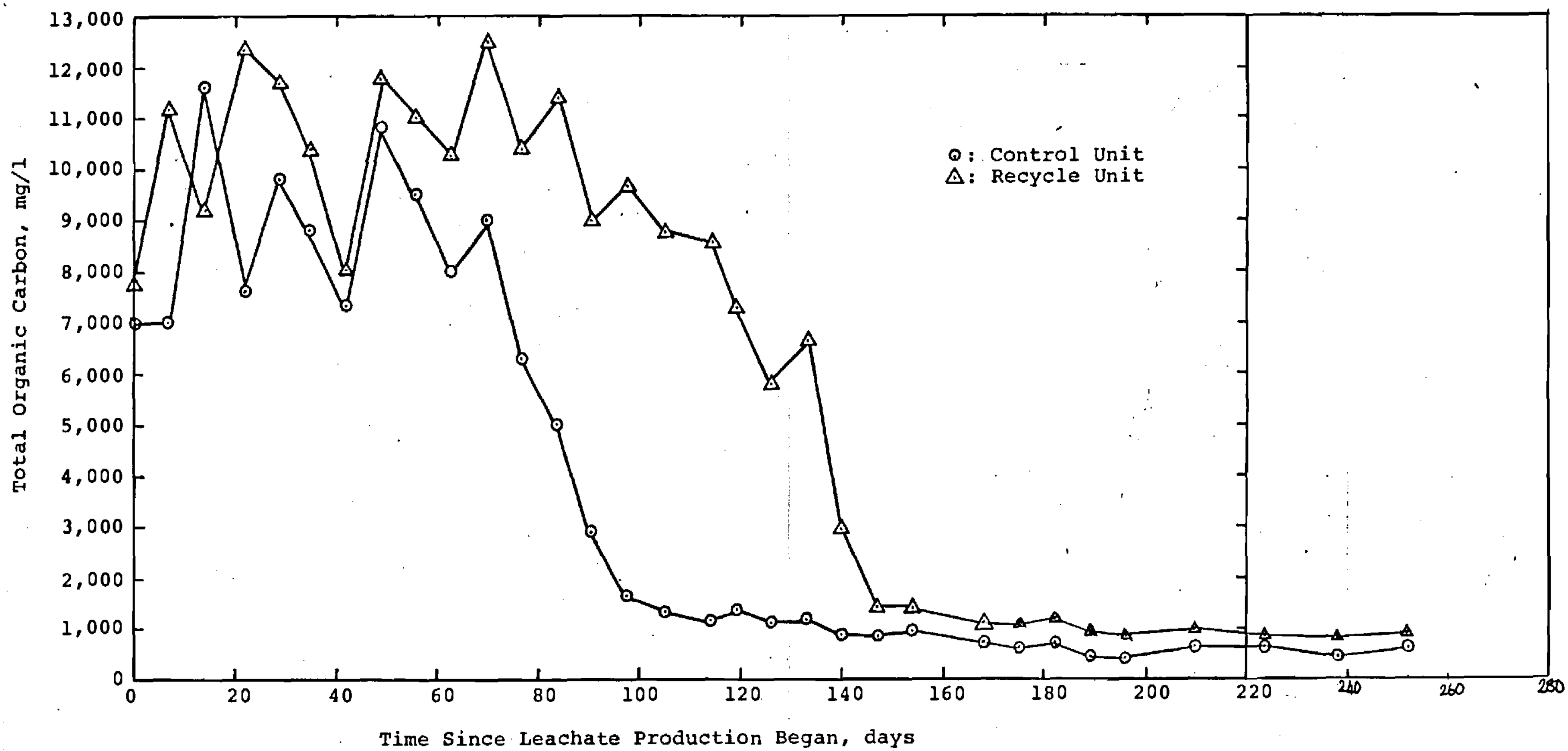



Figure 5. Total Organic Carben of Leachate

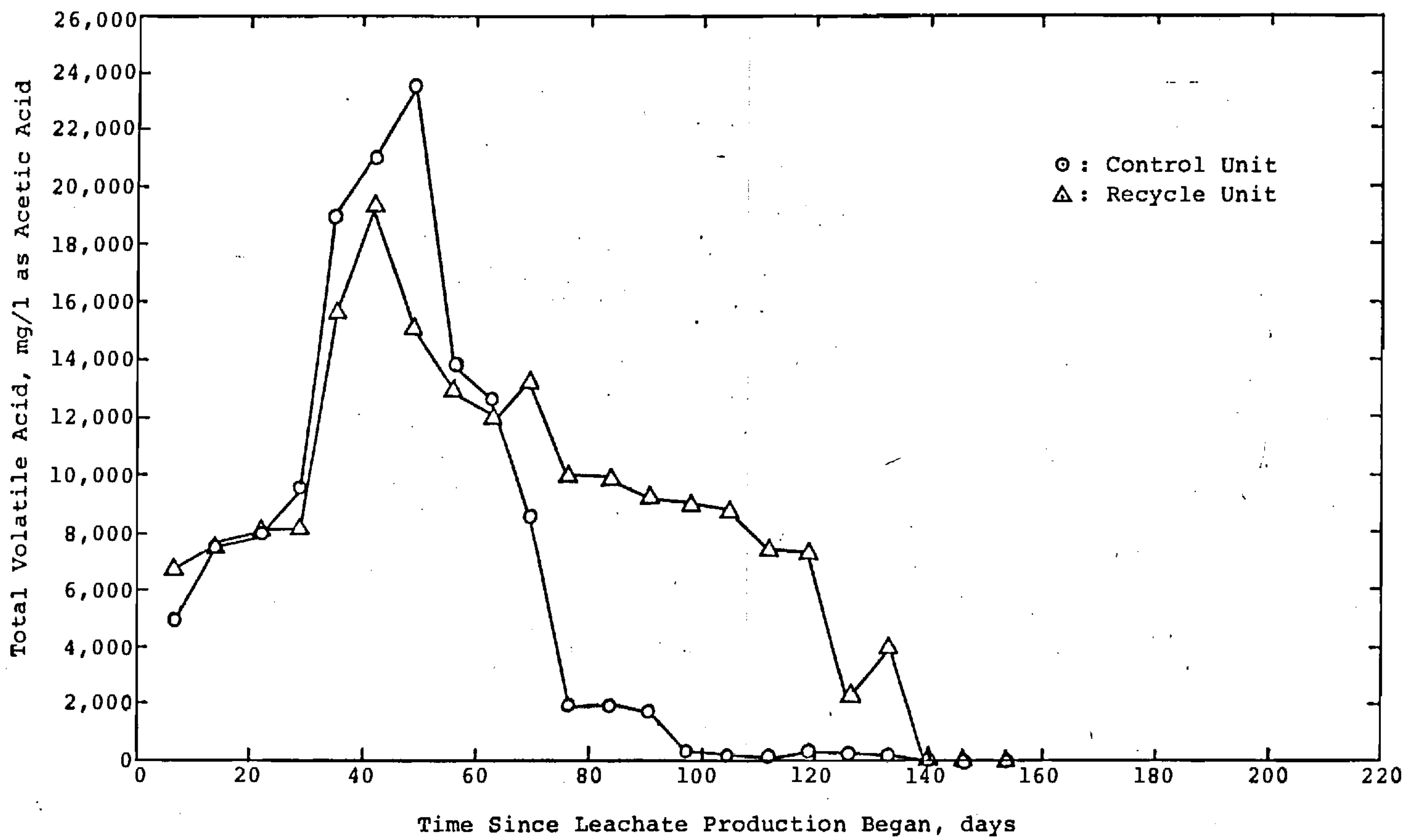



Figure 6. Total Volatile Acid of Leachate

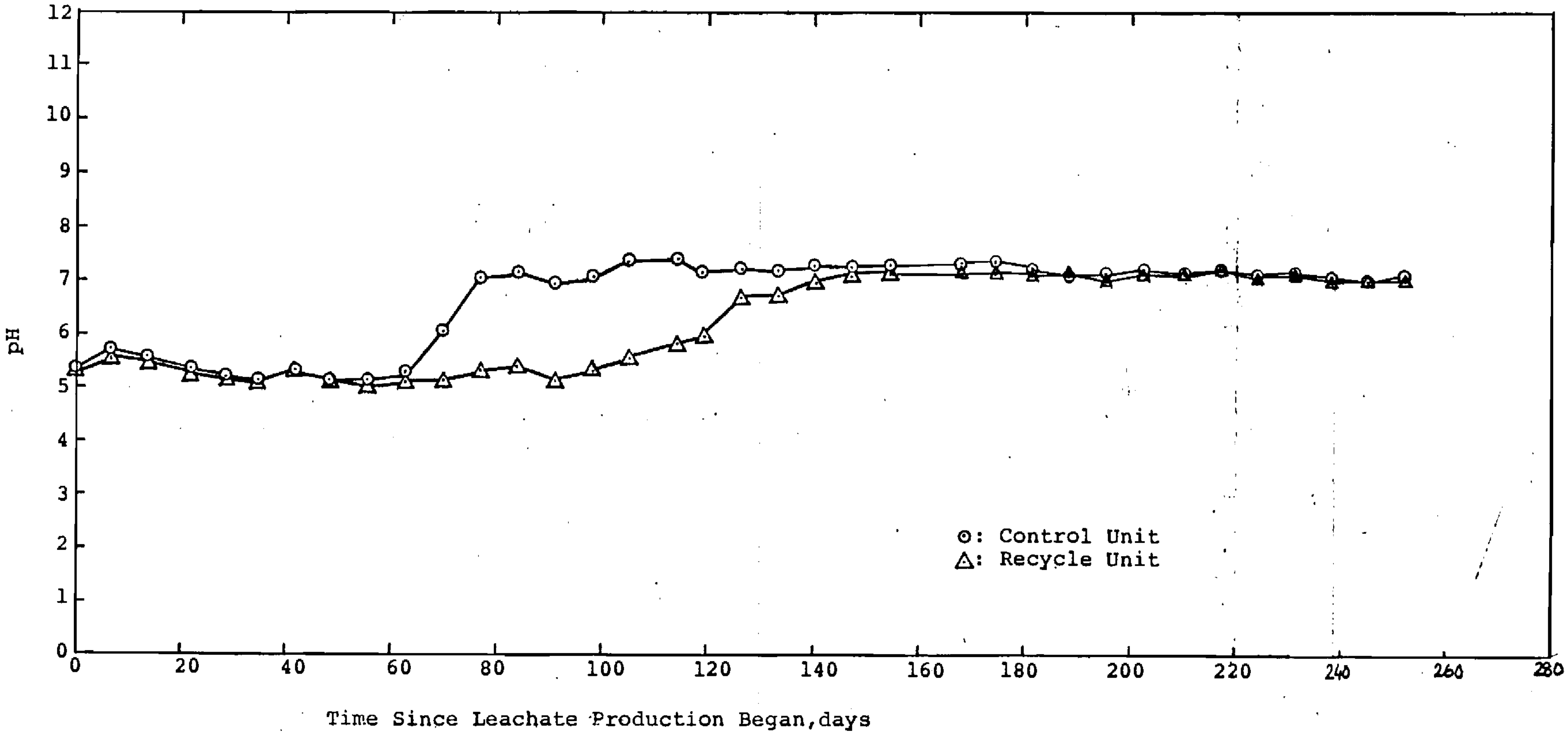



Figure 7. pH of Leachate

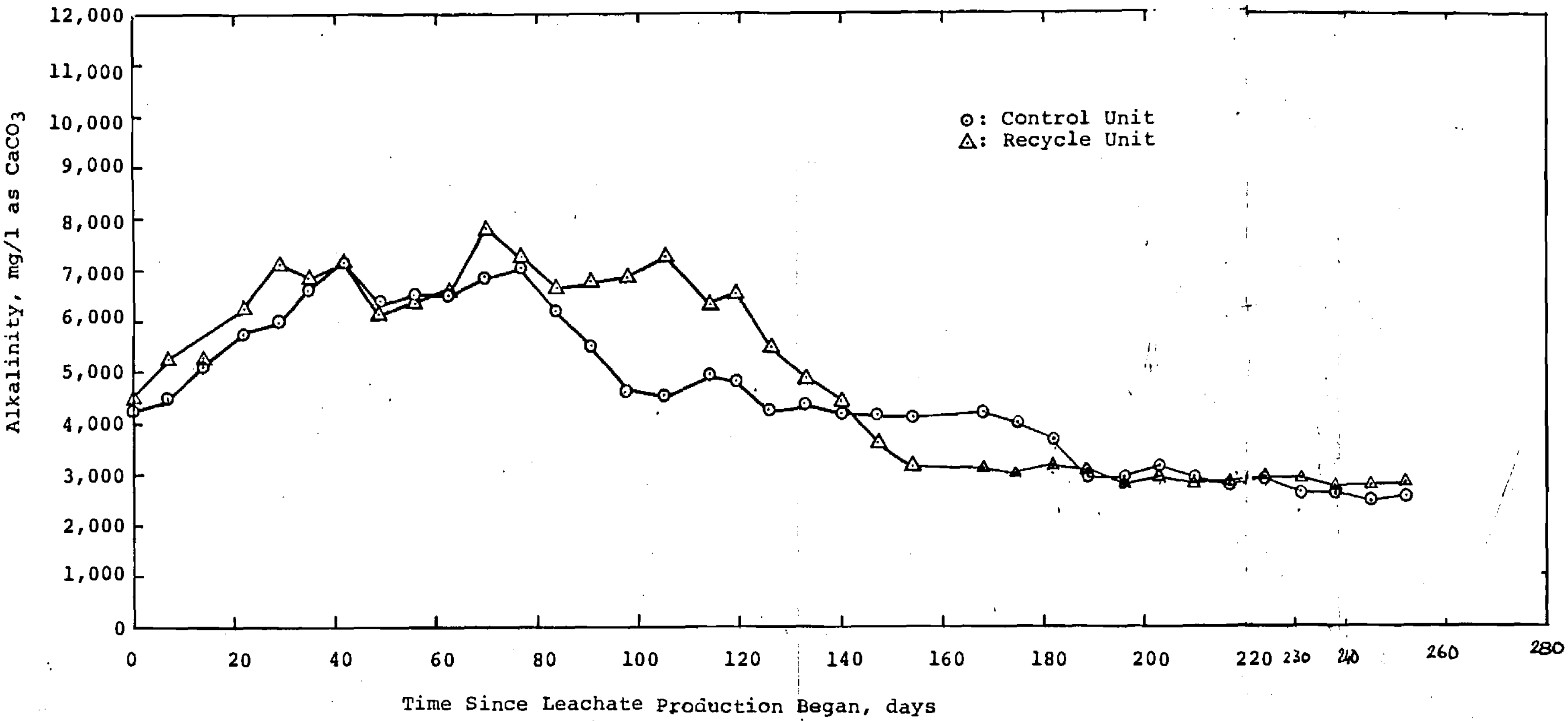



Figure 8. Alkalinity of Leachate

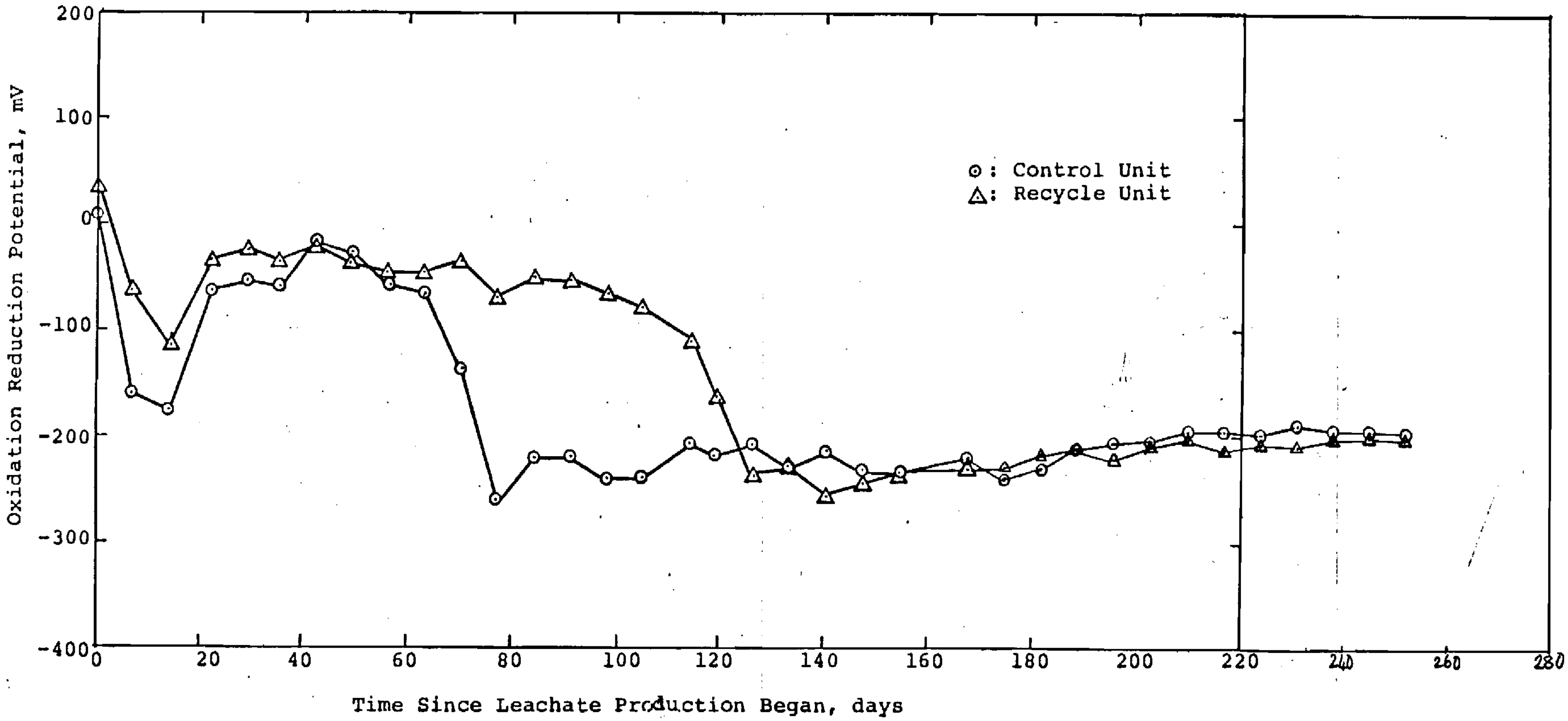
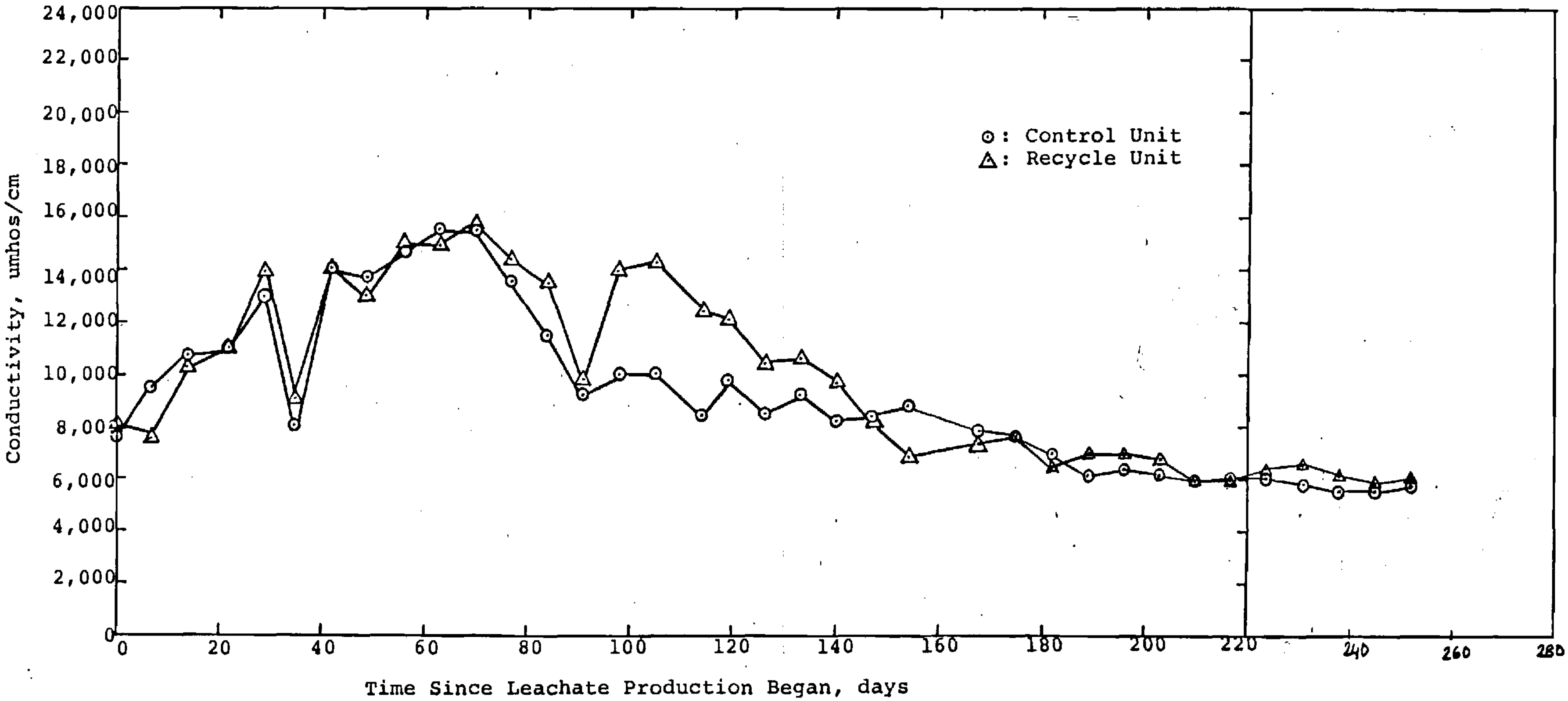



Figure 9.. Oxidation Reduction ~~Began~~, days




Figrue 10. Conductivity of Leachate

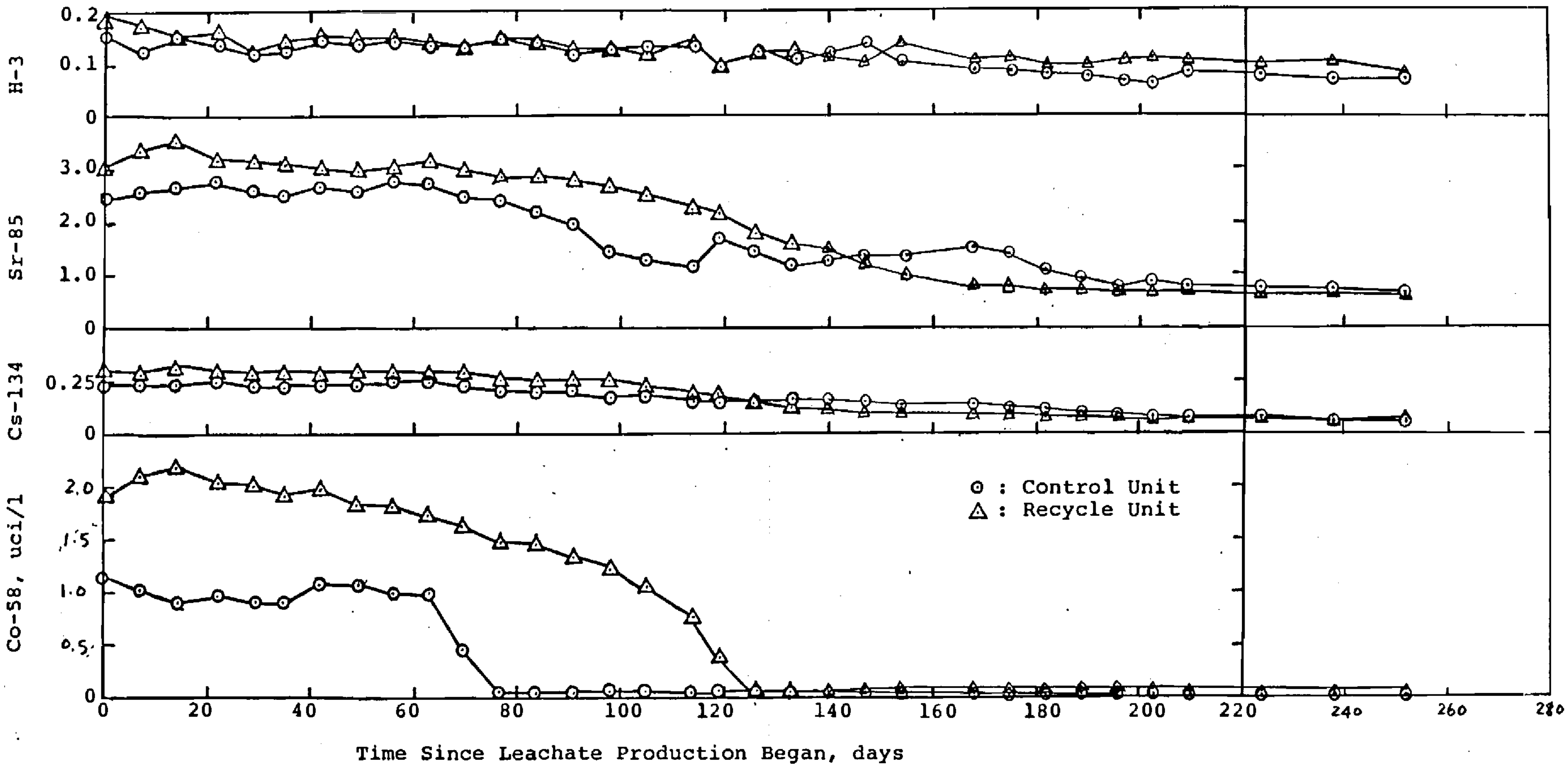



Figure 11. The Activity of Radionuclides in Leachate

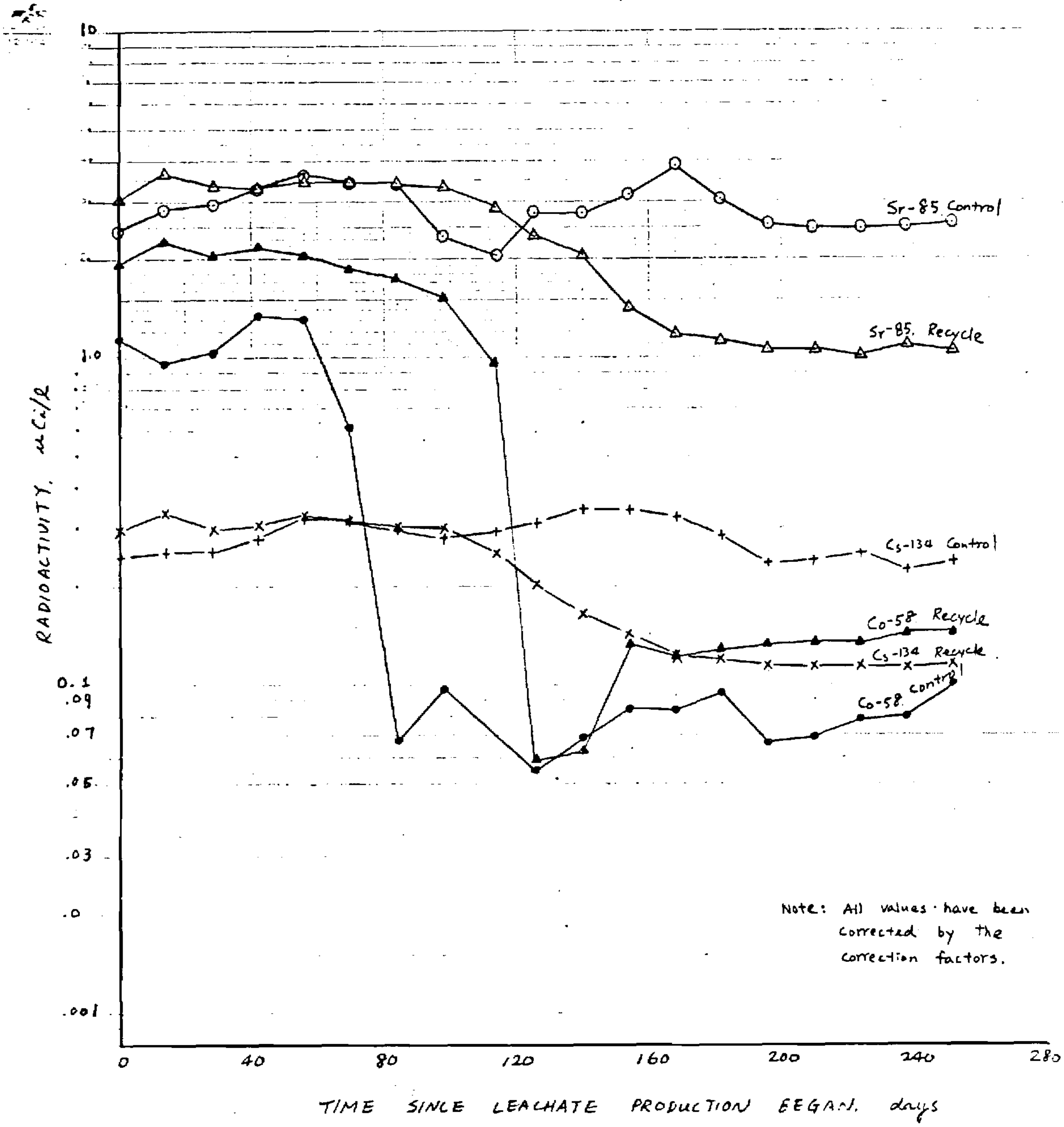

Sr-85 Control
Sr-85 Recycle
Cs-134 Control
Co-58 Recycle
Cs-134 Recycle
Co-58 Control
RADIOACTIVITY, uCi/l
TIME SINCE LEACHATE PRODUCTION BEGAN, days
Note: All values have been corrected by the correction factors.

Figure 12

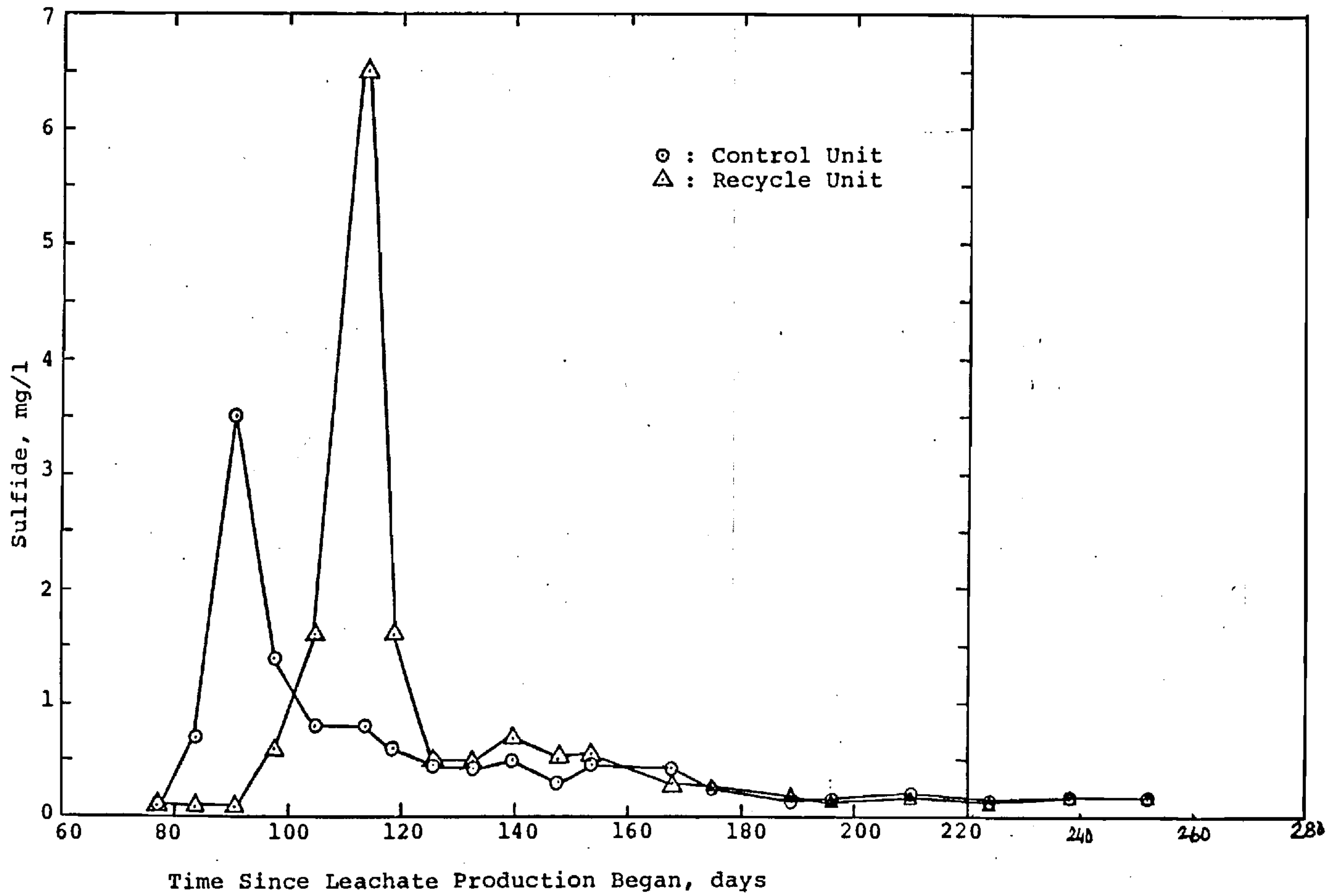
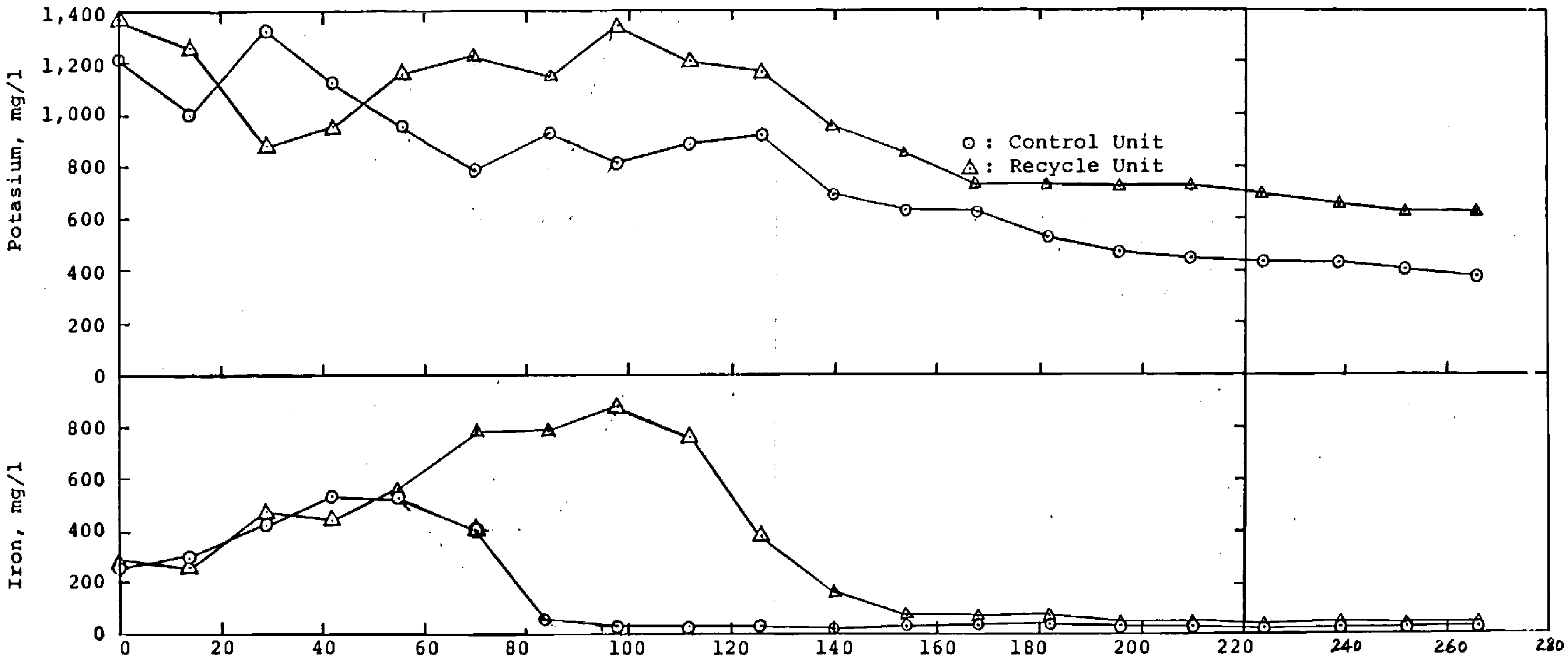



Figure 13. The Concentration of Sulfide of Leachate




Time Since Leachate Production Began, days

Figure 14. The Concentration of Iron and Potasium of Leachate

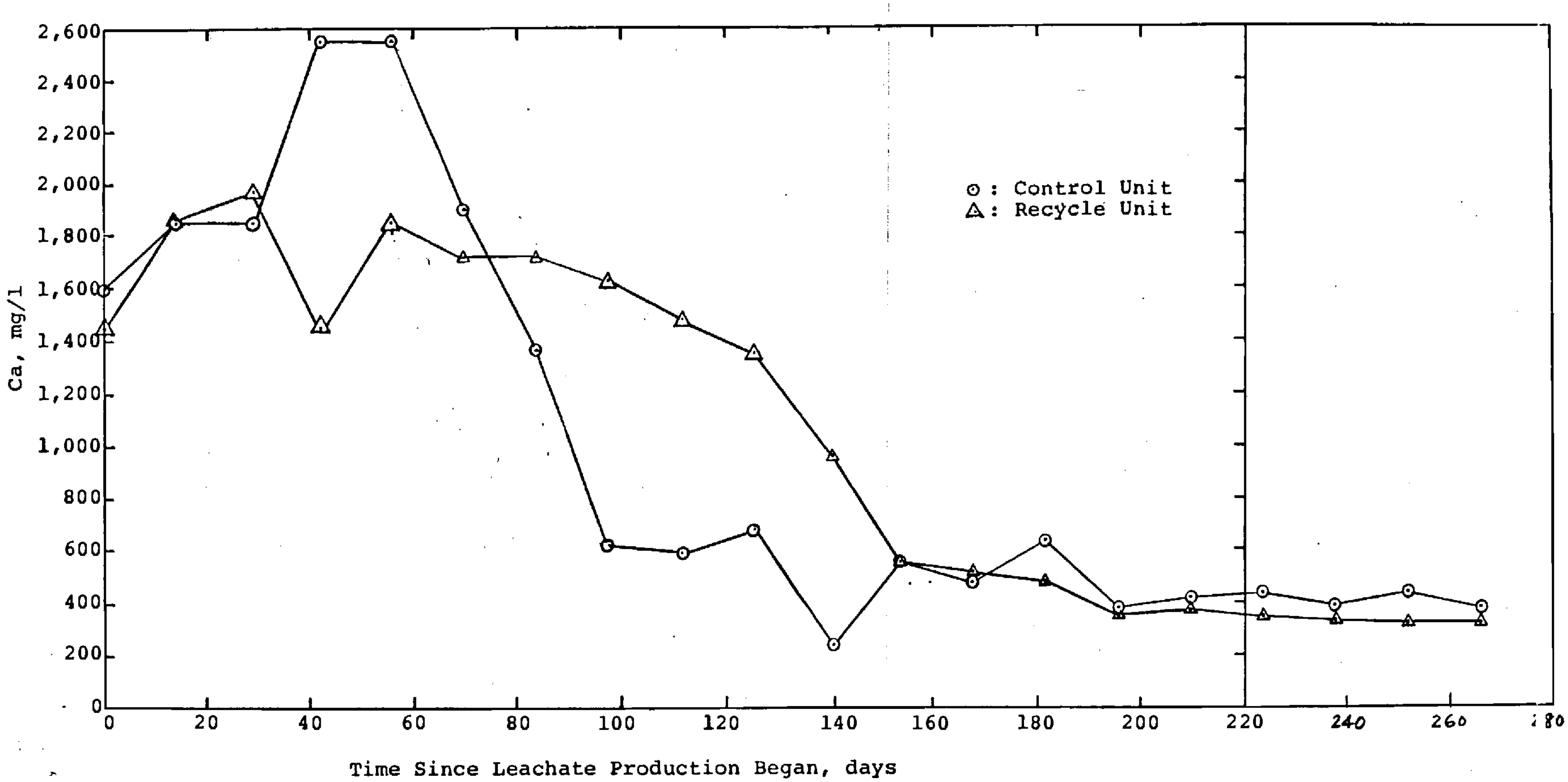



Figure 15. The Concentration of Calcium of Leachate

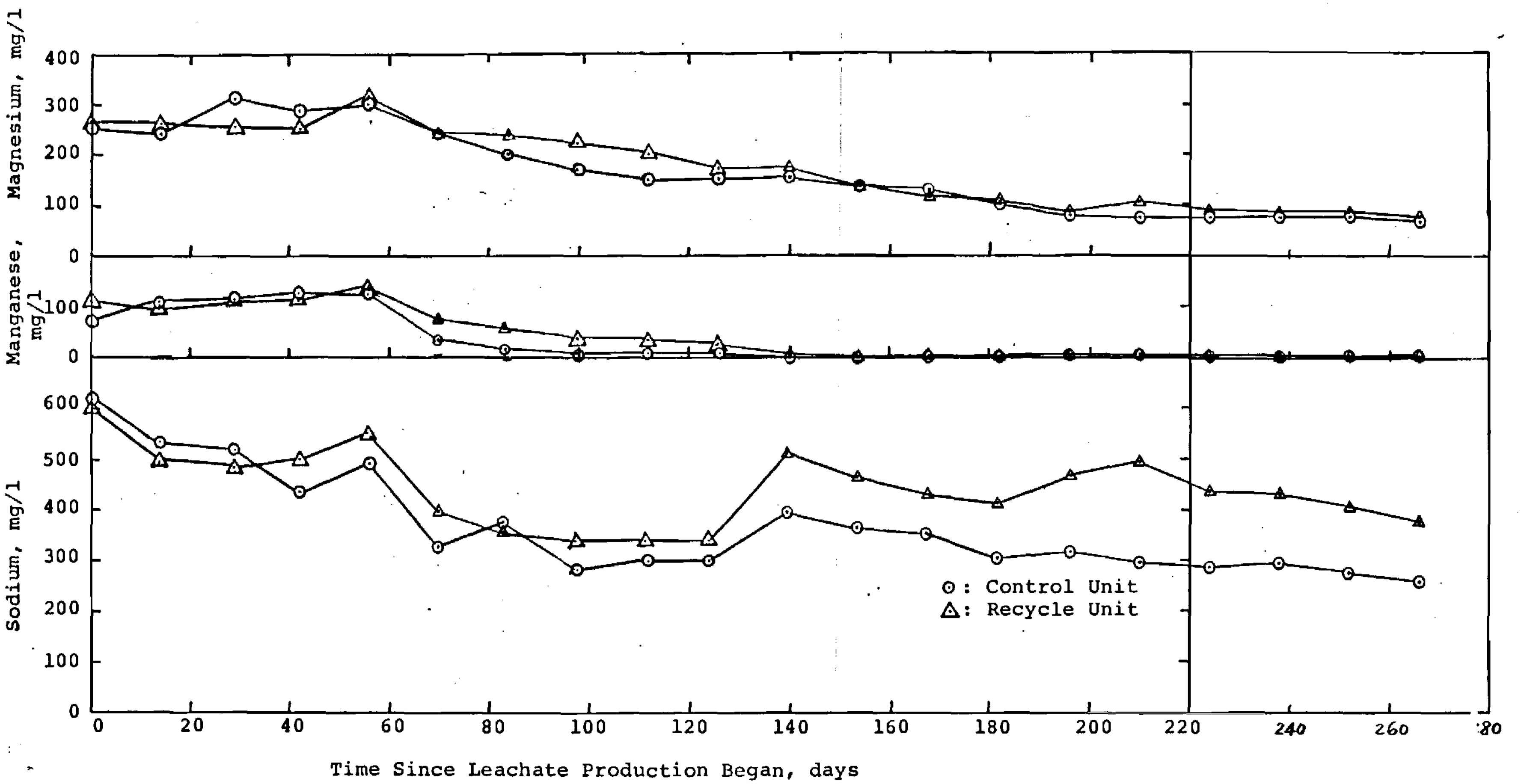



Figure 16. The Concentration of Sodium, Manganese and Magnesium of Leachate, mg/l

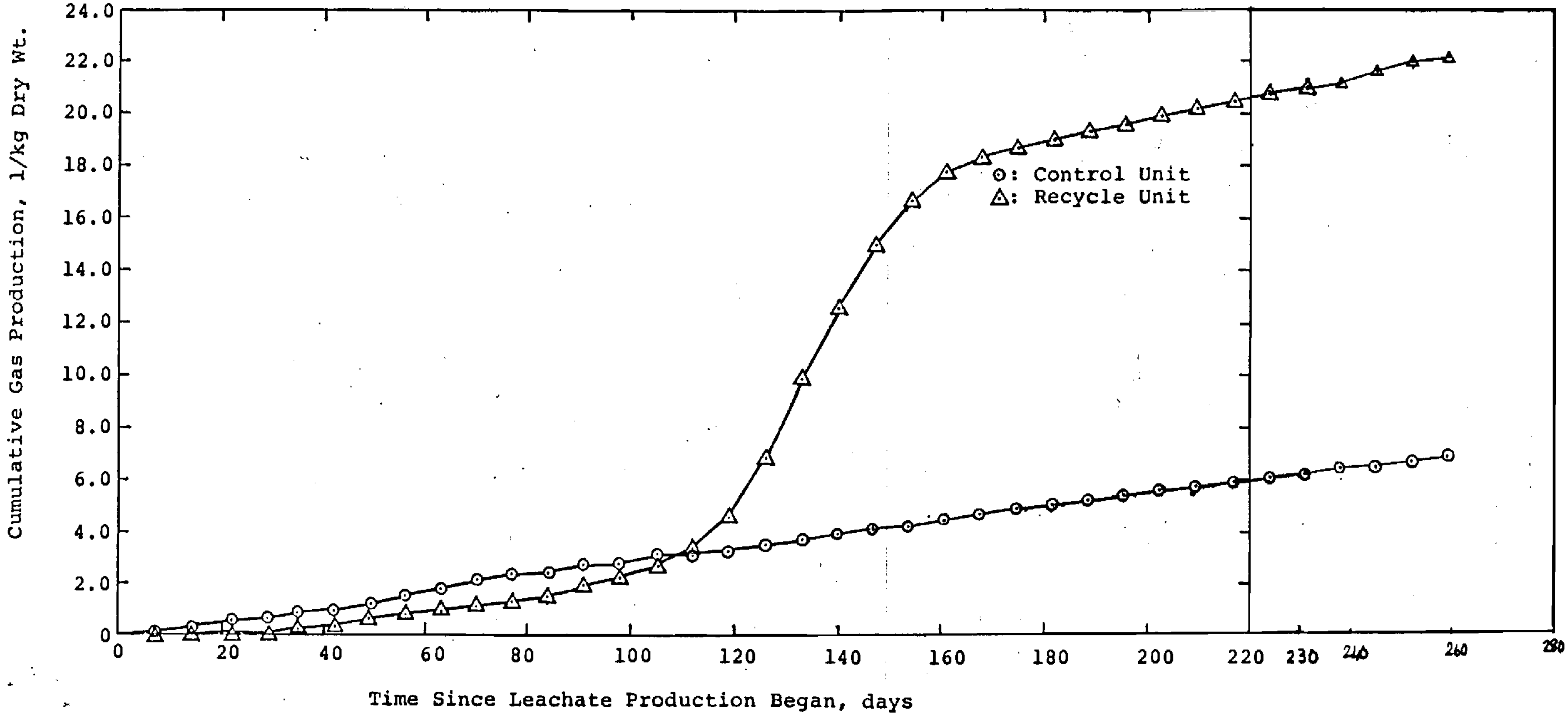



Figure 17. Cumulative Gas Production of The System

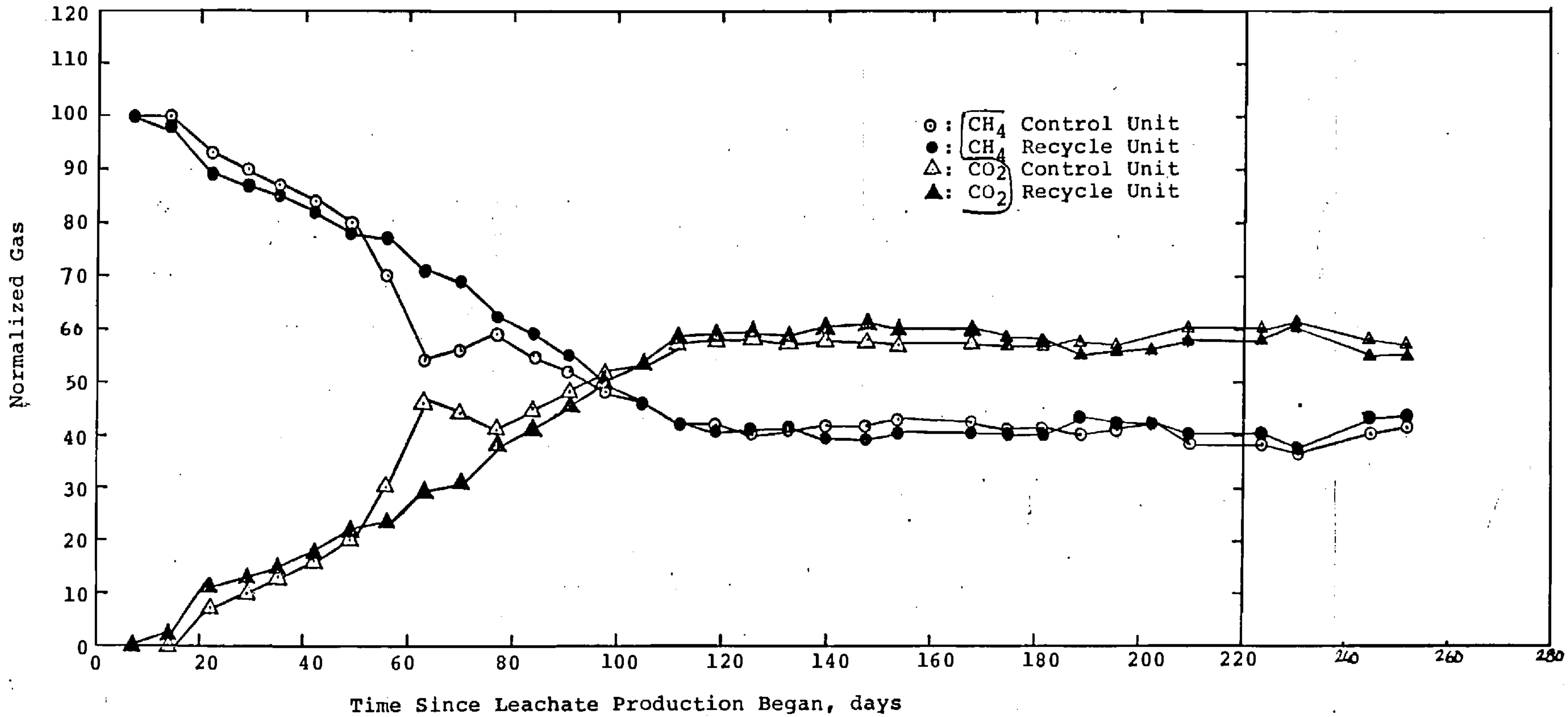



Figure 18. Normalized Gas Composition of the Controlled and Recycle Unit

# CO-DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE WITHIN SANITARY LANDFILLS

A THESIS

Presented to

The Faculty of the Division of Graduate Studies

By

Ker-Chi Chang

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

in the School of Civil Engineering

Georgia Institute of Technology

September, 1982