CHAPTER 4

RESULTS

4.1 Wastewater Characteristics and Soil Properties

4.1.1 Wastewater

The characteristics of domestic wastewater, serially collected for 21 times from grit chamber in Hauykwang Treatment Plant during November 1986 to March 1987, are summarized in **Table 4.1.** The tested wastewater was slightly basic, quite high in COD loading, heavy contamination of E.coli, dissolved of some ions, i.e., NH_4-N, orthophosphate, K, SO_4 and others; all of these ions, Cl content was the highest, followed by Na and Ca, respectively, and none of NO_3-N. There was little change in the chemical composition of the wastewater or influent over a 20-week period. All tested parameters could be serialy detected, but in different degree. The quantities of K, Mg, total P and orthophosphate seemed to be constant, whereas the quantities of Na, Ca, total N, NH_4-N, E.coli, and Cl were fluctuated. The last one was the highest in both variability and quantity **(Table 4.1).** The characteristics of the effluents or soil-treated wastewater are shown in **Appendix E.2-E.5.** The amounts of some parameters, for COD, NH_4-N, orthophosphate, cations, anions and faecal coliform were markedly reduced. Interestingly, the NO_3-N content in some effluent could be detected.

4.1.2 Soil Properties

Some physical, chemical and biological properties of each soil series are summaried in **Table 4.2** and **Appendix F.1.**

Table 4.1 Average value and range of some characteristics of the tested wastewater

Parameters	Range	Mean Value	n	σ_{n-1}
pH	7 - 8	7.80	18	0.16
COD (mg/l)	398 - 765	601.99	19	71.7
NH_4-N (mg/l)	40 - 58	48.55	19	5.7
NO_3-N (mg/l)	immeasurable low value	-	-	-
TKN (mg/l)	44 - 61	53.28	19	5.7
PO_4 (mg/l)	6 - 9	7.68	19	1.1
Total-P (mg/l)	8 - 12	9.82	19	1.0
Na (mg/l)	63 - 81	73.18	16	5.5
K (mg/l)	8 - 17	11.35	16	2.3
Ca (mg/l)	31 - 46	40.08	16	4.8
Mg (mg/l)	8 - 12	10.28	16	1.1
Cl (mg/l)	81 - 120	96.06	16	13.2
SO_4 (mg/l)	29 - 46	38.04	15	5.3
E.coli (mg/l)	$4.0x10^5$-$8.3x10^6$	$1.65x10^6$	13	-

Table 4.2 Average values and ranges of some properties of 4-tested soils.

characteristics	Pak Chong	Khamphaeng Saen	Muak Lek	Ban Bung
sand (%)	15.3	33.8	72.4	79.6
silt (%)	26.4	41.4	15.2	13.1
clay (%)	58.3	24.8	12.5	7.3
texture	clay	loam	sandy loam	loamy sand
pH	6.1-6.2	6.05-6.25	7.5	6.7-6.8
	6.17	6.13		6.75
TKN (%)	0.139-0.149	0.061-0.079	0.036-0.049	0.0112-0.0119
	0.144	0.073	0.081	0.0117
NH_4-N (%)	.0002-.0006	0-0.0004	0-.0002	0
	0.0005	0	0	0
NO_3-N (%)	0-.0002	.004-.0059	0	0
	0	0.0047	0	0
Total-P (ppm)	22.6-31.9	64.0-72.3	16.0-27.5	10.7-12.5
	28.00	67.43	20.71	11.56
Extract-P(ppm)	18.6-21.1	9.5-10.3	4.8-7.6	5.2-5.9
	19.65	9.76	6.18	5.46
Na (meq/100g)	0.16-0.21	0.25-0.30	0.20-0.59	0.14-0.21
	0.18	0.27	0.38	0.18
K (meq/100g)	0.07-0.11	0.27-0.34	0.14-0.17	0.03-0.04
	0.09	0.31	0.16	0.033
Ca (meq/100g)	12.39-14.66	10.18-11.91	15.67-18.56	4.90-6.61
	13.49	11.5	17.46	5.67
Mg (meq/100g)	1.39-1.82	2.85-3.44	0.32-0.42	0.06-0.08
	1.56	3.19	0.39	0.07
Cl (meq/100g)	0.028-0.034	0.084-0.10	0.028-0.084	0.017-0.022
	0.027	0.092	0.045	0.018

Table 4.2 (ต่อ)

characteristics	Pak Chong	Khamphaeng Saen	Muak Lek	Ban Bung
SO_4 (meq/100g)	0.015-0.021	0.028-0.034	0.015-0.023	0.027-0.037
	0.019	0.031	0.019	0.032
Organic C (%)	0.85-1.16	0.72-0.76	0.30-0.42	0.08-0.19
	0.96	0.73	0.37	0.13
CEC (meq/100g)	16.17-19.82	8.27-9.37	7.76-8.90	2.85-3.39
	18.07	9.37	8.48	3.01
E. coli (col/g)	nil	nil	nil	nil

The texture of four soil series used in this experiment were Pak Chong clay, Khamphaeng Saen loam, Muak Lek sandy loam and Ban Bung loamy sand. The percentage of clay size particles in Pak Chong serie was higher than in Khamphaeng Saen soil series about 33.45%. Percentages of sand in four-tested soil were 15.3, 33.8, 72.4 and 79.6 in Pak Chong, Khamphaeng Saen, Muak Lek and Ban Bung series, respectively. The mean values of some parameters were similar to those from the Soil Map of Thailand (77,78,79,80),i.e., Ban Bung soil series, the value of Ca, Mg, K and Na were 0.4, 0.1, 0.05, 0.2 meq/100g, respectively. The content of CEC in Pak Chong series was very high (18.07 meq/100g) followed by Khamphaeng Saen (9.37 meq/100g),Muak Lek (8.48 meq/100g) and Ban Bung series (3.01 meq/100g), respectively. It supports that Pak Chong soil series is slightly fertile while Ban Bung soil series is sharply low fertile (82).

4.2 Characteristics of Treated Wastewater, Effluent and Soils

4.2.1 Soil Permeability

The average amount of added wastewater per day into Pak Chong, Khamphaeng Saen, Muak Lek and Ban Bung soil series are equal 939, 97, 785 and 1197 ml, respectively. Permeability of four-tested soil series were conducted by determining volumes of added wastewater in each soil column, i.e., the more the amount of water is added, the more the soil permeability increased. Twenty-four hours after applying 5 liters of wastewater to each soil series, about 50% of the total amounts of the wastewater were added into Ban Bung, Pak Chong and Muak Lek soil series, i.e., 2500, 2400 and 2150 ml,respectively, but in Khamphaeng Saen series, the added volume or influent was quite small, 50-100 ml only. After 2 weeks, the volume of the added wastewater in Ban Bung series was nearly constant, about 1000 ml/day, through out

the period of experiment. However, in Pak Chong and Muak Lek soil series, they were slightly increased until 14 weeks. The average values of the influent in four-tested soil series are shown weekly in **Figure 4.1.** The best permeability was Ban Bung soil series and followed by Pak Chong and Muak Lek soil series. The least one was Khamphaeng Sean soil series.

4.2.2 pH

4.2.2.1 pH of the Influent and Effluent

The pH of influent and effluent are shown in **Figure 4.2.** The influent was slightly alkaline with the average of 7.80. The pH ranges of the effluent from each soil series were narrow, about of 7.31-9.0. The average pH of effluent from Khamphaeng Saen, Pak Chong, Muak Lek and Ban Bung soil series were 8.20, 8.11, 8.00 and 7.94, respectively. Initially, pH of the effluent from all soil series were slightly increased, compared with the influent, and after six weeks, pH from Khamphaeng Saen effluent was remained increasingly. After 14 weeks, the pH from Muak Lek and Ban Bung effluent were decreased, and lower than the pH of the influent.

4.2.2.2 Soil pH

Soil pH of Muak Lek, Ban Bung, Pak Chong, and Khamphaeng Saen soil series were 7.50, 6.75, 6.17 and 6.13, respectively. After 20-week treatment with wastewater, soil pH was slightly increased in the same trend in each sections of all soil series. The average values of Muak Lek, Khamphaeng Saen and Pak Chong soil series were 7.73, 6.56 and 6.50, respectively, whereas pH in Ban Bung series were sharply increased from 6.75 to 7.77 **(Figure 4.3 and Appendix F.2-F.3).**

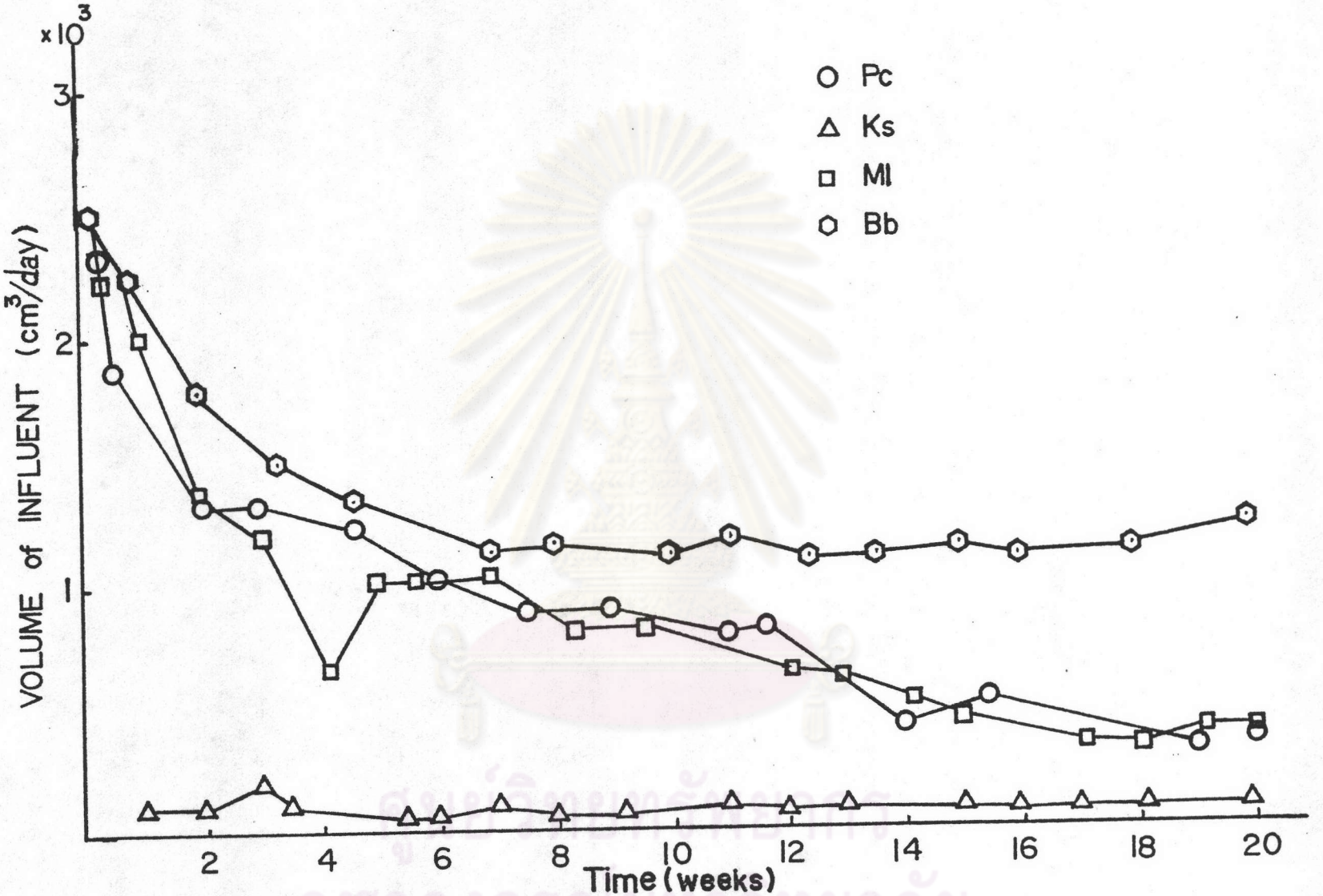

Figure 4.1 Soil Percolation rate of wastewater in soil series

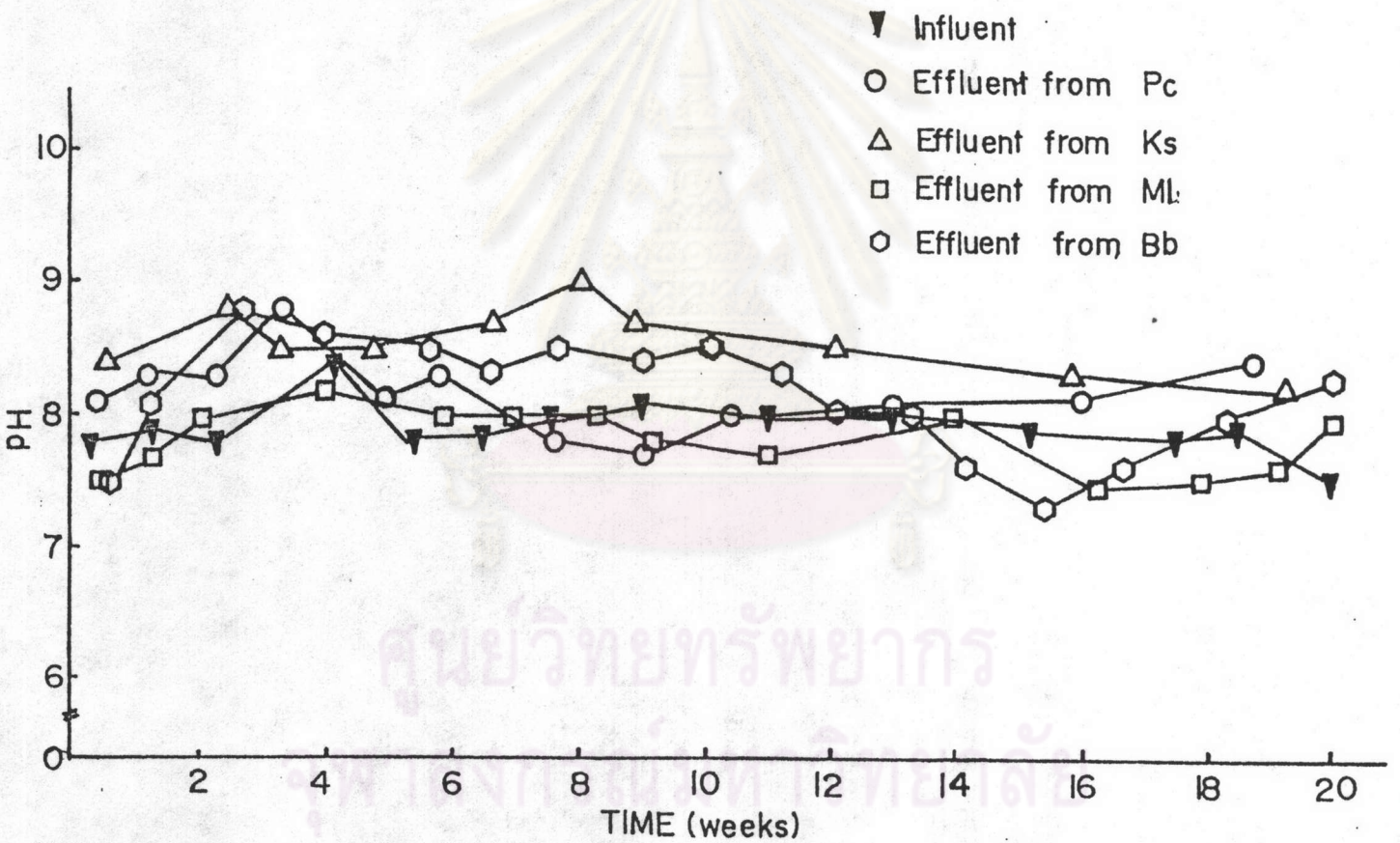

Figure 4.2 pH in the influent and effluent from soils

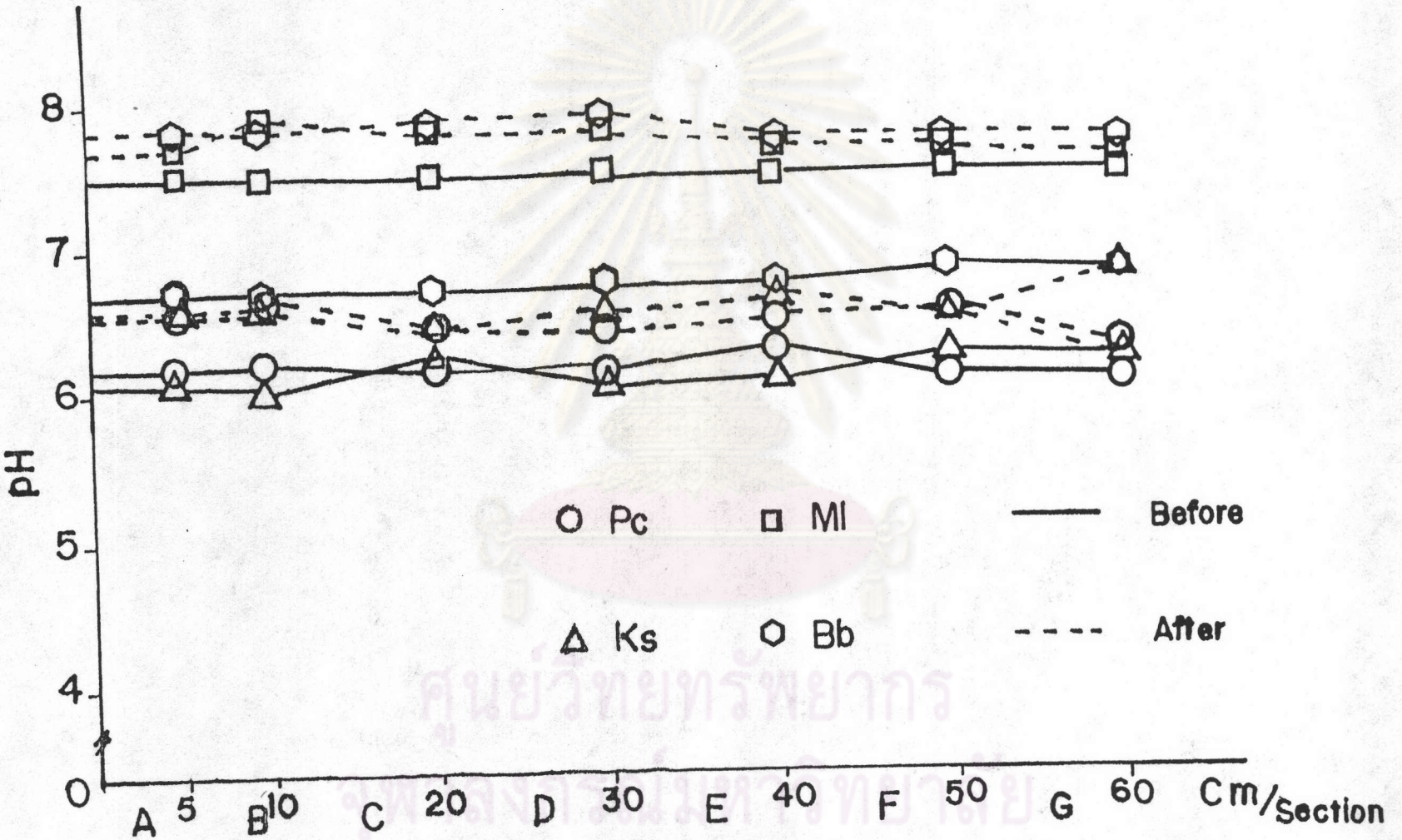

Figure 4.3 pH of the soil before and after passing with wastewater

4.2.3 Nitrogen Content

4.2.3.1 Nitrogen Content in Influent and Effluent

Total kjedahl nitrogen in the influent was 53.28 mg/l and highly composed of NH_4-N with the average value of 48.55 mg/l (**Figure 4.4** and **Appendix E.1-E.5**). There was a small amount of organic nitrogen and none of NO_3-N. Under continuous treatment of 20 weeks with wastewater, NH_4-N from Pak Chong, Muak Lek and Ban Bung effluent were lowest in the first two weeks, i.e., 0, 16.24 and 16.61 mg/ml, respectively, and then gradually increased during week-3 to week-7. After 7 weeks, NH_4-N in the effluent would gradually decrease again whereas NO_3-N would gradually increase at this period. NO_3 contents in the effluent from three soil series, except from Khamphaeng Saen series, were more than 6.0 mg/l, and the highest content of NO_3-N was found from Muak Lek effluent. It was shown the different trend of the content of nitrogen species in the effluent. No NO_3-N could be found from Khamphaeng Saen effluent and also the content of NH_4-N was gradually decreased from 26.12 to 0.44 mg/l during the period of experiment. The results showed that the amounts of NH_4-N in the effluent from all tested soil series decreasing compared with its contents in influent and the amounts of NO_3-N had increased from zero to be detectable from Pak Chong, Muak Lek and Ban Bung effluent except from Khamphaeng Saen effluent.

4.2.3.2 Nitrogen Content in Soil

From **Figure 4.5** and **Appendix F.2-F.3**, the percentage of total kjedahl nitrogen content were markedly increased in all soil sections (A-G) of the four-tested soil series. The highest increment of total kjedahl nitrogen level was found in Muak Lek

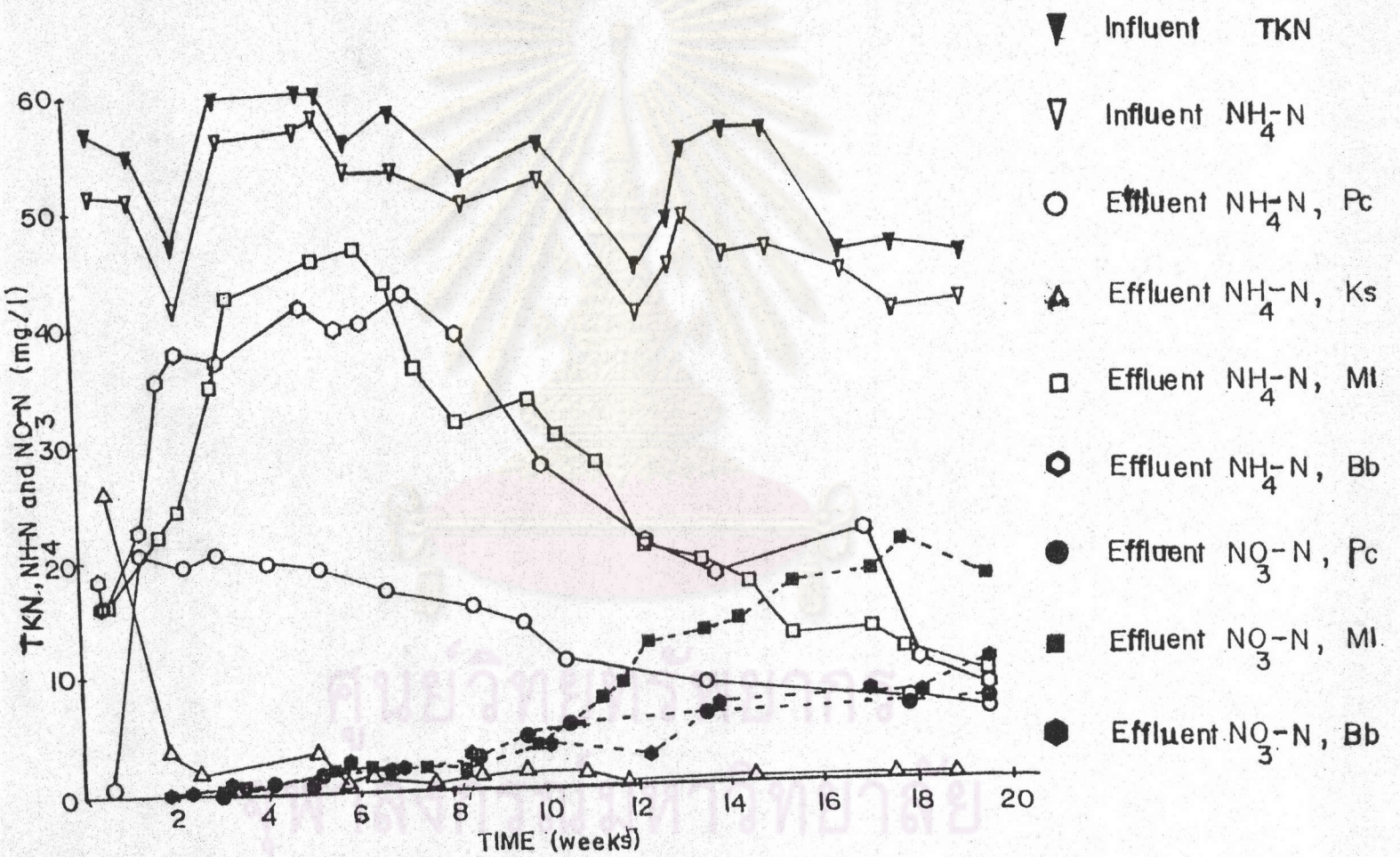

Figure 4.4 Total N, NH_4-N and NO_3-N in the influent and effluent from soils

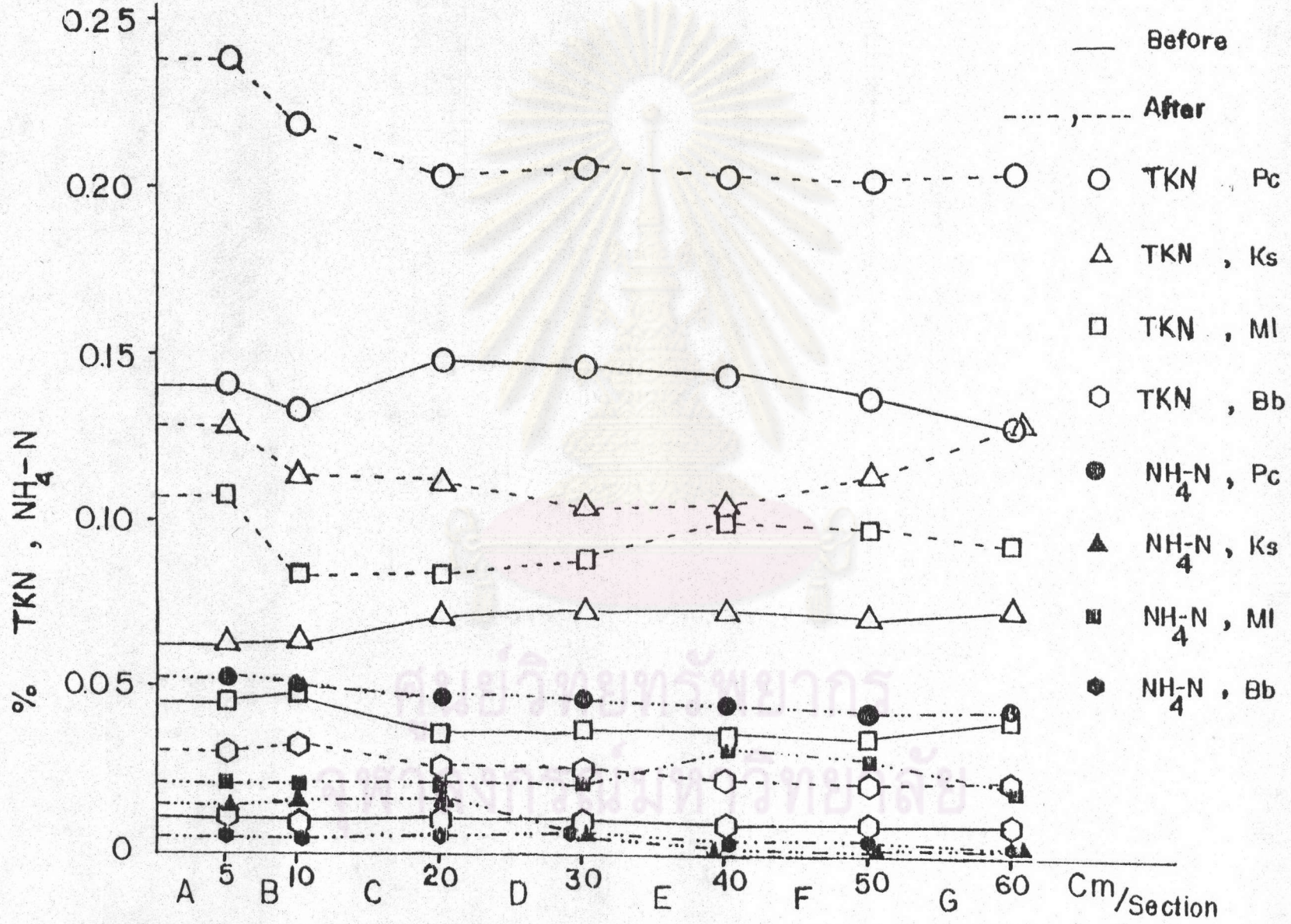

Figure 4.5 Total N, NH_4-N and NO_3-N of the soil before and after passing with wastewater

(2.33 times) and followed by Ban Bung (2.31 times), Khamphaeng Saen (1.63 times) and Pak Chong (1.49 times), respectively. Similarly, NH_4-N content were also markedly increased in all soil sections, i.e., the average of 130 times increment occured in all section of Pak Chong soil about 22.25 times in 6 sections of Khamphaeng Saen soil except in section C which increased from zero to 0.0157%. In the last 2 soil series, the content of NH_4-N increased from 0 to .0243 % in Muak Lek soil and to .0063 % in Ban Bung soil. Eventhough, the increased amount of NH_4-N in Ban Bung was less than in Muak Lek soil series. Occuring in only three soil series, Pak Chong, Muak Lek and Ban Bung soil series, the amounts of NO_3-N in all soil sections after wastewater treatment were increased from zero to a very small amount. Thus, soil NO_3-N could be detected in all soil sections. After wastewater treatment, the amounts of NO_3-N in Khamphaeng Saen soil series were decreased in section B-G whereas they were almost the same level in all sections A.

4.2.4 Phosphorus Content

4.2.4.1 PO_4-P Content in Influent and Effluent

Total phosphorus and orthophosphate in the wastewater or influent are found in the range of 8.32-11.93 mg/l and 6.10-9.11 mg/l with the average values were 9.82 and 7.68 mg/l, respectively. **Figure 4.6** and **Appendix E.1-E.5** showed that orthophosphate could be detected from Muak Lek and Ban Bung effluent after 4-week treatment of wastewater and then gradually increased until the end of 20-week treatment, whereas small amount of orthophosphate could be detected from Pak Chong effluent but undetectable from Khamphaeng Saen effluent.

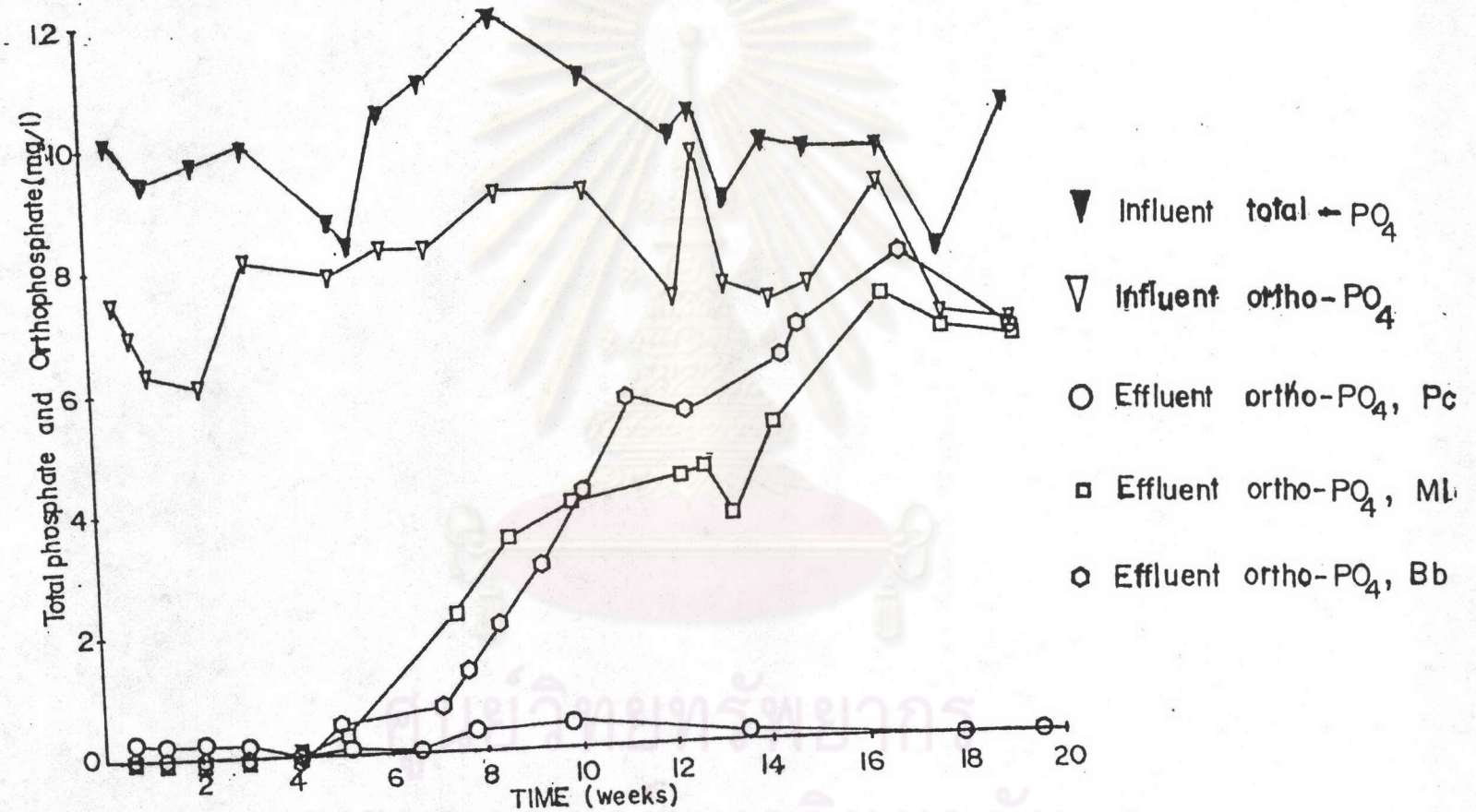

Figure 4.6 Total phosphate and orthophosphate in the influent and effluent from soils

4.2.4.2 Phosphorus content in Soil

Figure 4.7 and **Appendix F.2-F.3** present the total phosphorus and extractable-P content in the four-tested soil series. After treatment of wastewater, the amounts of total-P in all soil series were increased with different degree. In section A, the amount of total-P was sharply increased in Pak Chong series, from 31.88 to 142.81 ppm or 4.48 times, then from 20.25 to 48.25 ppm or 2.38 times in Muak Lek soil, from 64.0 to 102.19 ppm or 1.59 times in Khamphaeng Saen soil and from 12.50 to 17.83 ppm or 1.43 times in Ban Bung soil series. However, the amounts of total-P were also sharply increased in section B and C of the Pak Chong soil series, whereas they were gradually increased in Ban Bung soil series from section A to G. It was shown that the average amounts of total-P were increased in all soil series, that was, from 28.00 to 101.20 ppm or 3.62 times in Pak Chong soil,from 11.56 to 28.11 ppm or 2.45 times in Ban Bung soil, from 20.71 to 42.83 ppm or 2.16 times in Muak Lek soil and from 67.43 to 77.86 ppm or 1.17 times in Khamphaeng Saen soil series **(Appendix F.2-F.3)**.

The amount of extractable-P were slightly increased in Pak Chong, Khamphaeng Saen and Ban Bung soil series. Especially, in sections D, E and G of Ban Bung soil series, their contents were double. Contrary, the extractable-P contents in section A-D and G of Muak Lek series were slightly decreased. Anyway, the average amounts of extractable-P were slightly increased in 3 soil series, i.e., from 5.5 to 10.2 ppm or 1.87 times in Ban Bung from 1.97 to 2.34 ppm or 1.19 times in Pak Chong and 9.7 to 10.4 ppm or 1.06 times in Khamphaeng Saen soil series. In Muak Lek series, it was slightly decreased from 6.1 to 6.0 ppm **(Appendix F.2-F.3)**.

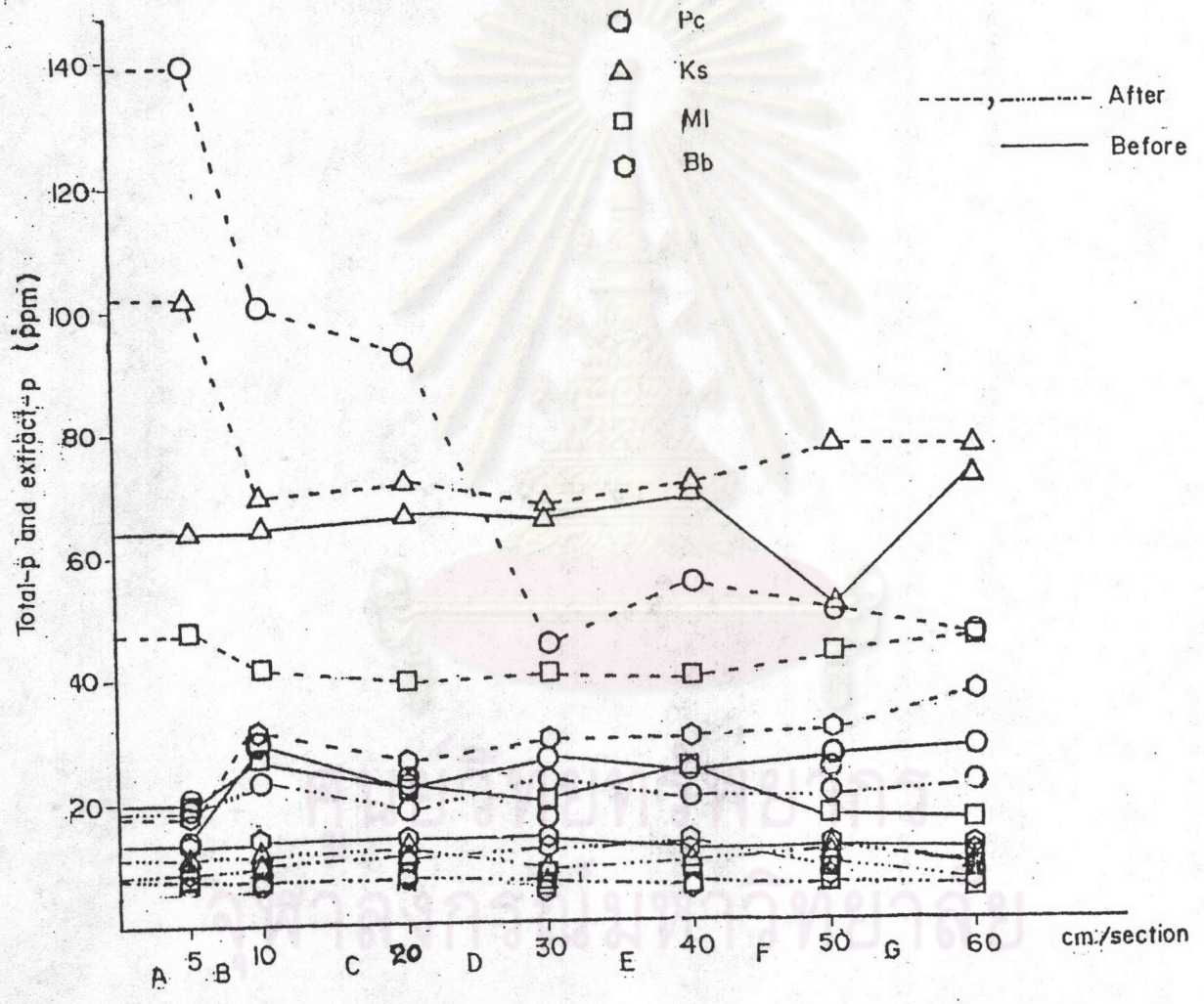

Figure 4.7 Total phosphate and orthophosphate of the soil before and after passing with wastewater

4.2.5 Cations Content

4.2.5.1 Na Content in Influent and Effluent

Figure 4.8 and **Appendix E.1-E.5** present the concentration of Na in the influent and the effluent from four-tested soil series. The concentration of Na from Khamphaeng Saen effluent markedly increased from 30 to 75.59 mg/l within 6 weeks, then its content from this soil series gradually increased to 102.06 mg/l at the end of 16-week treatment. And also the Na content from Muak Lek effluent increased from 48.07 to 70.73 mg/l within 6 weeks also. Then, it was nearly constant and almost equal to the Na content in the influent. However, Na content from Pak Chong effluent increased from 52.40 to 68.29 mg/l within 2 weeks. Then, it gradually decreased to 63.59 until the end of treatment. And again, it turned to increase and be higher than Na content in the influent until the end of the experiment. In contrast, Na from Ban Bung effluent was sharply increased from 30.0 to 65.12 mg/l in the first week, after that it was constant about 71.57 mg/l and little lower than the average value of Na content in the influent.

4.2.5.2 Na Content in Soil

The exchangeable Na of the four soil series are shown in **Figure 4.9** and **Appendix F.2-F.3** . After 20-week treatment of wastewater, their content in each section of each soil series were increased. However, the increment rate of exchangeable Na content in different sections of Muak Lek and Ban Bung soil series were not equal. The quantity of Na content from seven sections (A-G) of Muak Lek soil series were 0.06, 0.11, 0.37, 0.39, 0.20, 0.26 and 0.25 meq/100g or 1.10, 1.19, 2.68, 2.95, 1.51, 1.74 and 1.74

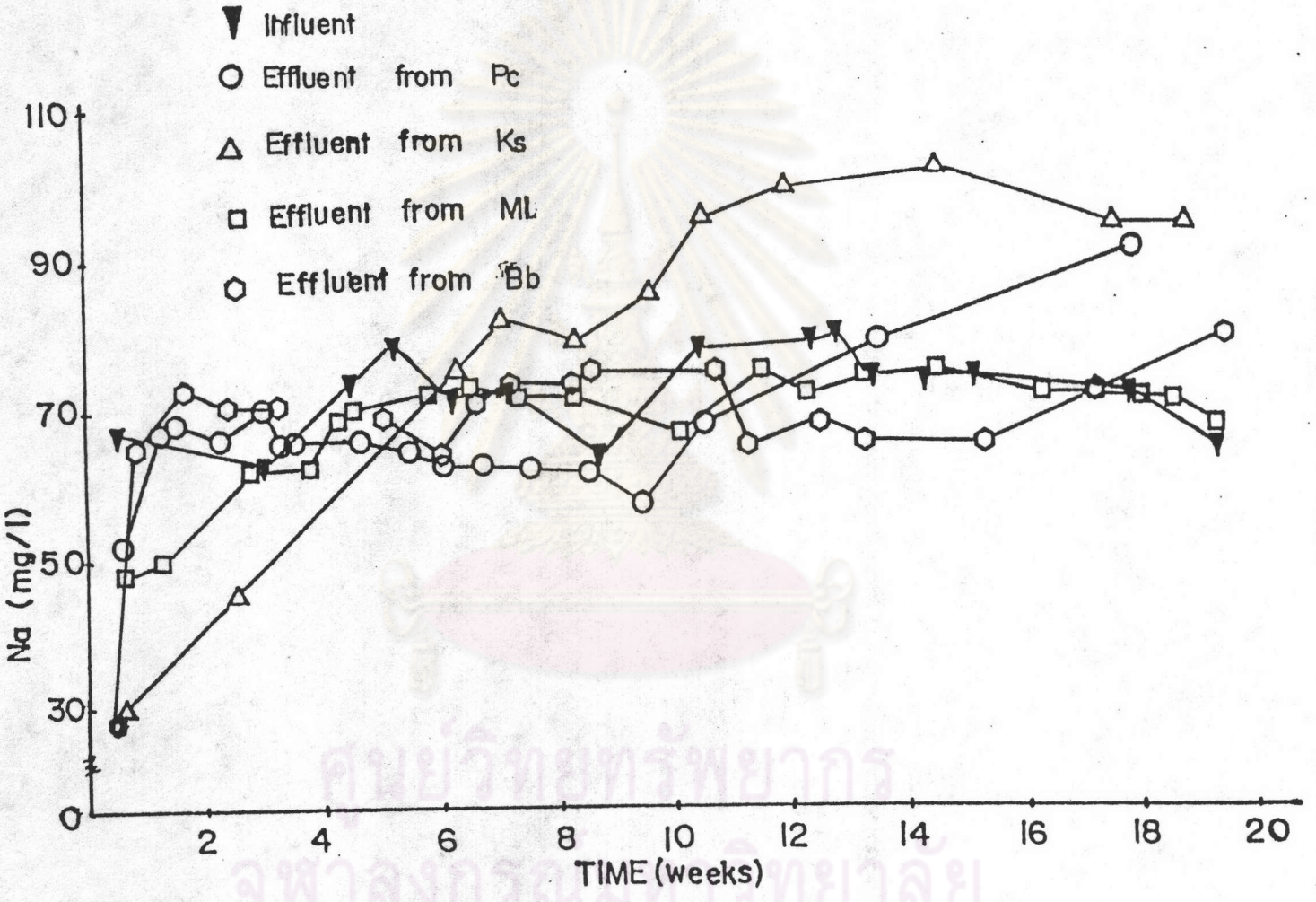

Figure 4.8 Soluble Na in the influent and effluent from soils

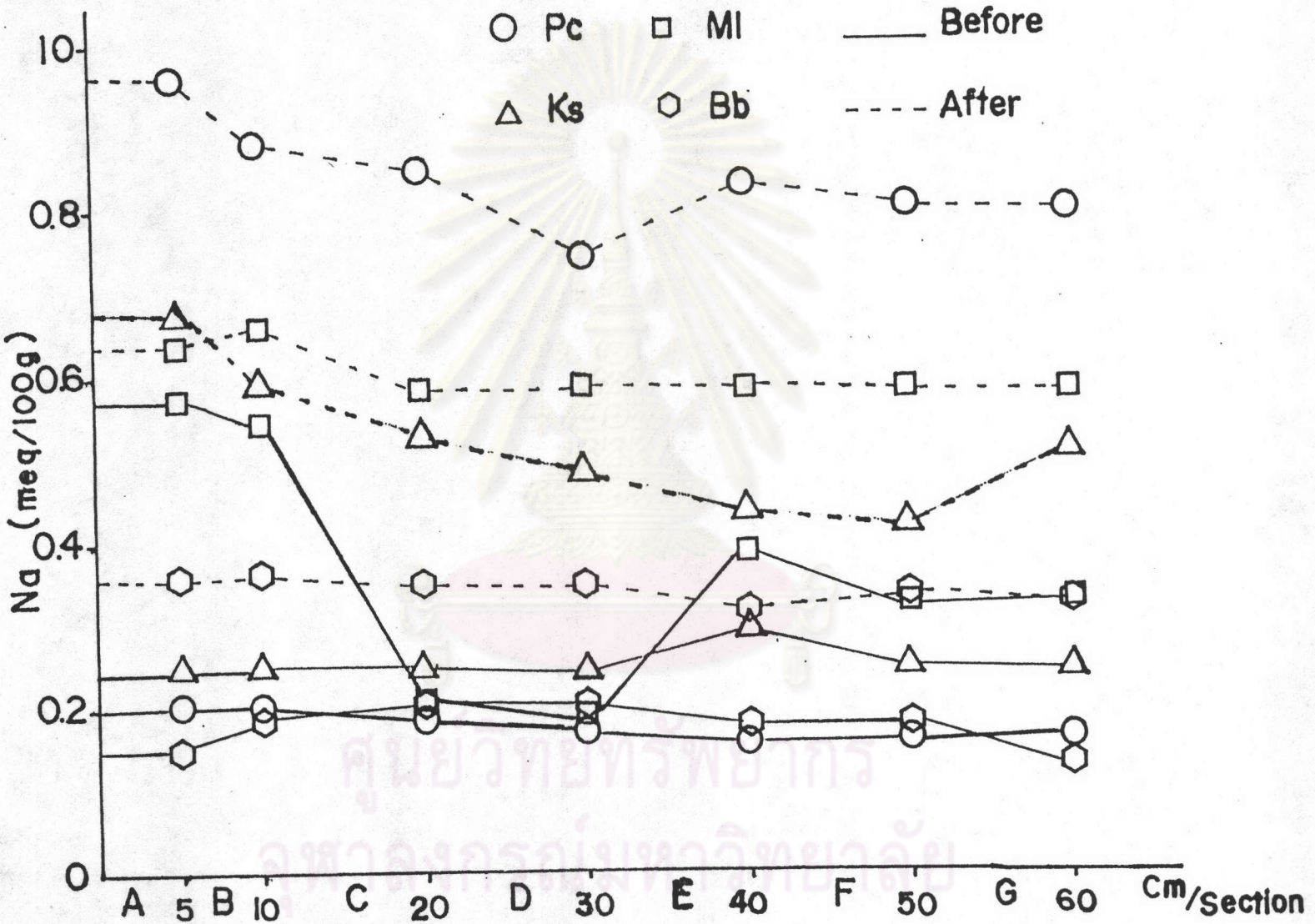

Figure 4.9 Exchangeable Na of the soil before and after passing with wastewater

times, and Ban Bung series are 0.19, 0.17, 0.15, 0.15, 0.14, 0.16 and 0.19 meq/100g, respectively, or 2.12, 1.85, 1.71, 1.67, 1.22, 1.89, 2.43 times. It is noticed that, after treatment of wastewater for 20-week, the total amounts of exchangeable Na in each section of the two soil series were almost constant, i.e., 0.32-0.37 meq/100g for Muak Lek soil series and 0.59-0.67 meq/100g for Ban Bung soil series. The exchangeble Na content in Pak Chong soil series were sharply increased in all sections, that was, from 0.21 to 0.97 meq/100g or 4.62 times. Similarly, its content in Khamphaeng Saen soil series were also increased but in lower degree, that was, from 0.26 to 0.68 meq/100g or 2.62 times. It could be concluded that, the highest increment of exchangeble Na content was occured in Pak Chong soil series.

4.2.5.3 K Contents in Influent and Effluent

The concentration of K in influent and the effluent from four-tested soil series was shown in **Figure 4.10** and **Appendix E.1-E.5.** Initially, their content , in the effluent from Pak Chong, Muak Lek and Ban Bung soil were lower than its content in the influent in the first 3-week treatment, then followed by gradually increasing and ended up with their total amounts were higher than K content in the influent. Contrary, its content from Khamphaeng Saen effluent were higher than K content in the influent all the period of experiment, with the average concentration was 23.71 mg/l.

4.2.5.4 K Content in Soil

The K content in four tested soil series before and after treatment of wastewater are shown in **Figure 4.11** and **Appendix F.2-F.3.** Except in Khamphaeng Saen soil series, the initial amount of K in Ban Bung, Pak Chong and Muak Lek soil

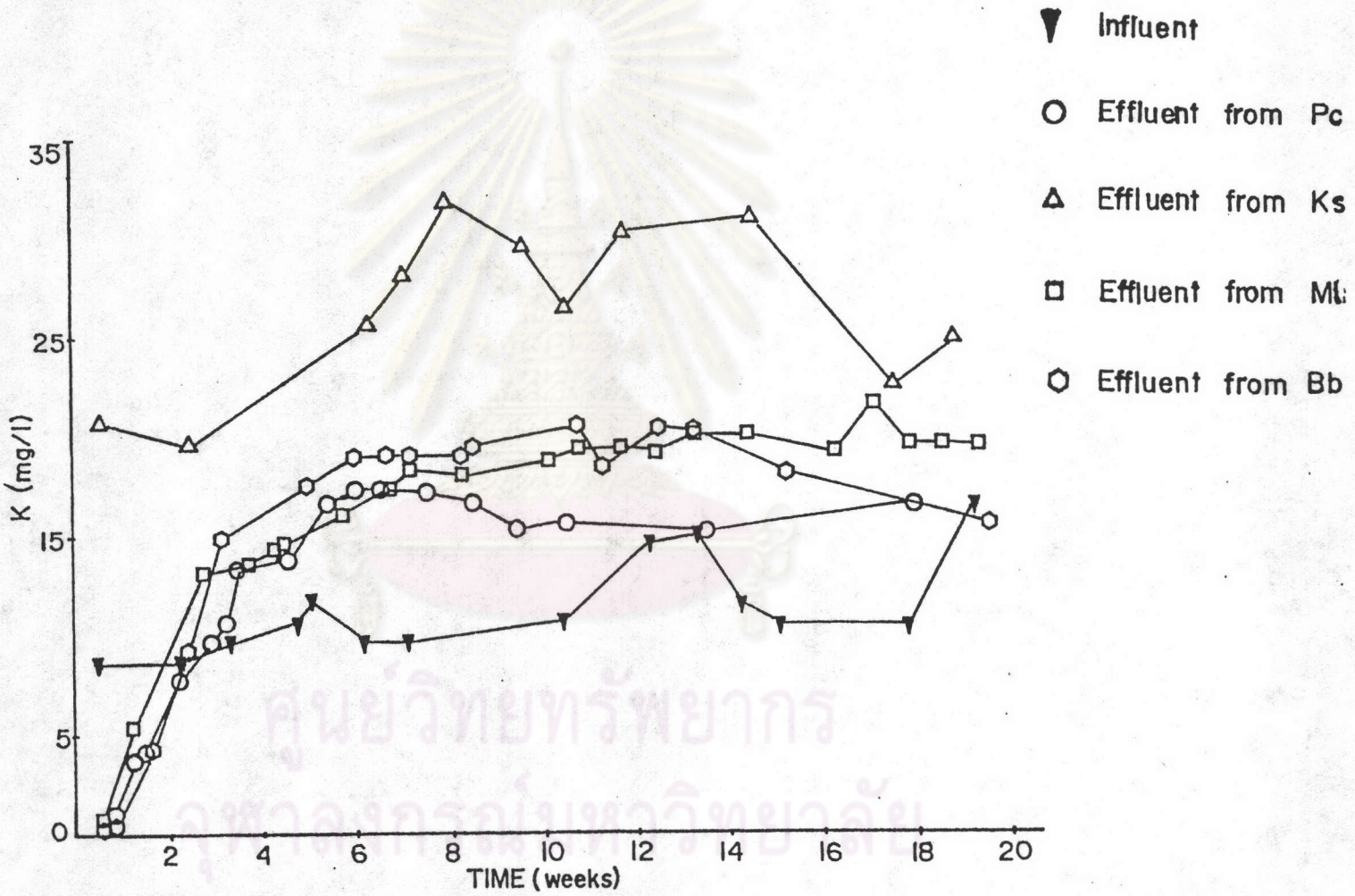

Figure 4.10 Soluble K in the influent and effluent from soils

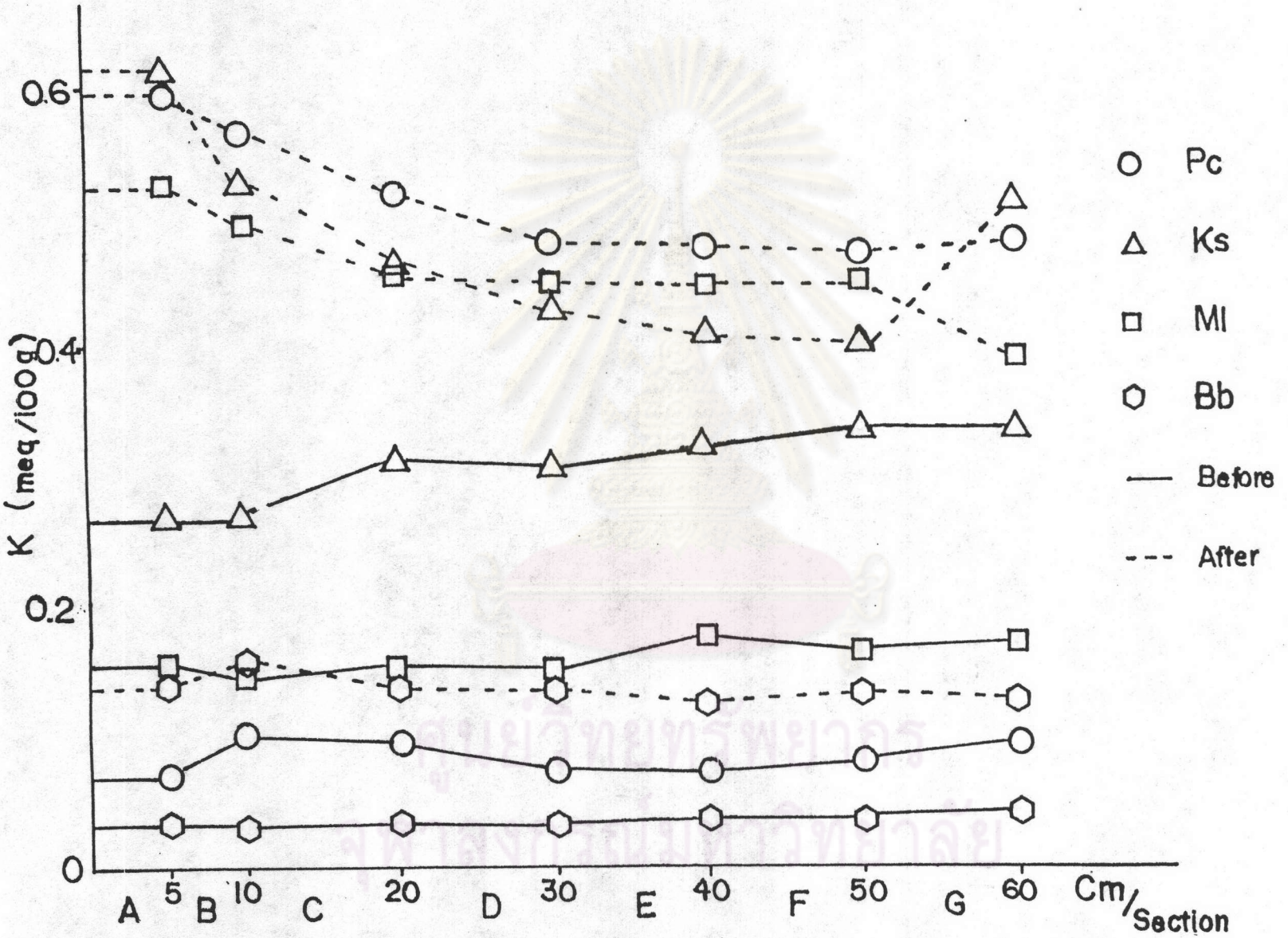

Figure 4.11 Exchangeable K of the soil before and after passing with wastewater

series were lower than the optimum content of K in fertile land, i.e.,0.15-0.25 meq/100g (57). After 20-week wastewater treatment, their content in all sections of all soil series were higher than the initial state but in different degree. The average content of K were from 0.09 to 0.50 meq/100g or 5.91 times in Pak Chong soil series, from 0.31 to 0.47 meq/100g or 1.55 times in Khamphaeng Saen, from 0.16 to 0.45 meq/100g or 2.90 times in Muak Lek and 0.04 to 0.14 meq/100g or 3.99 times in Ban Bung. Eventhough, K content in the last soil series was increased but the total amount of exchangeable K in this series had been continuously lower than optimum content. In Pak Chong soil series, the K content in section A was sharply increased, i.e., from 0.07 to 0.59 meq/100g or 8.43 times but in other soil section (B-G), their content were increased only 5 times. Anyway, the total K content in Pak Chong and Muak Lek soil series after wastewater treatment were nearly equal or about 0.50 meq/100g.

4.2.5.5 Ca Content in Influent and Effluent

Figure 4.12 and **Appendix E.1-E.5** show the total amounts of Ca in both the influent or wastewater and in the effluent from four soil series,i.e., Pak Chong, Khamphaeng Saen, Muak Lek and Ban Bung series. Except Ban Bung soil series, their content in the effluent sharply decreased in the first 4 weeks, and then gradually declined and some were slightly fluctuated. In Ban Bung effluent, Ca content was firstly increased and then gradually decreased which was lower than its content in the influent. In the period of experiment, Ca content from Pak Chong and Muak Lek effluents were higher than its content in the influent, whereas Ca content from Khamphaeng Saen effluent was changed from higher to lower than its content in the influent at the sixth week.

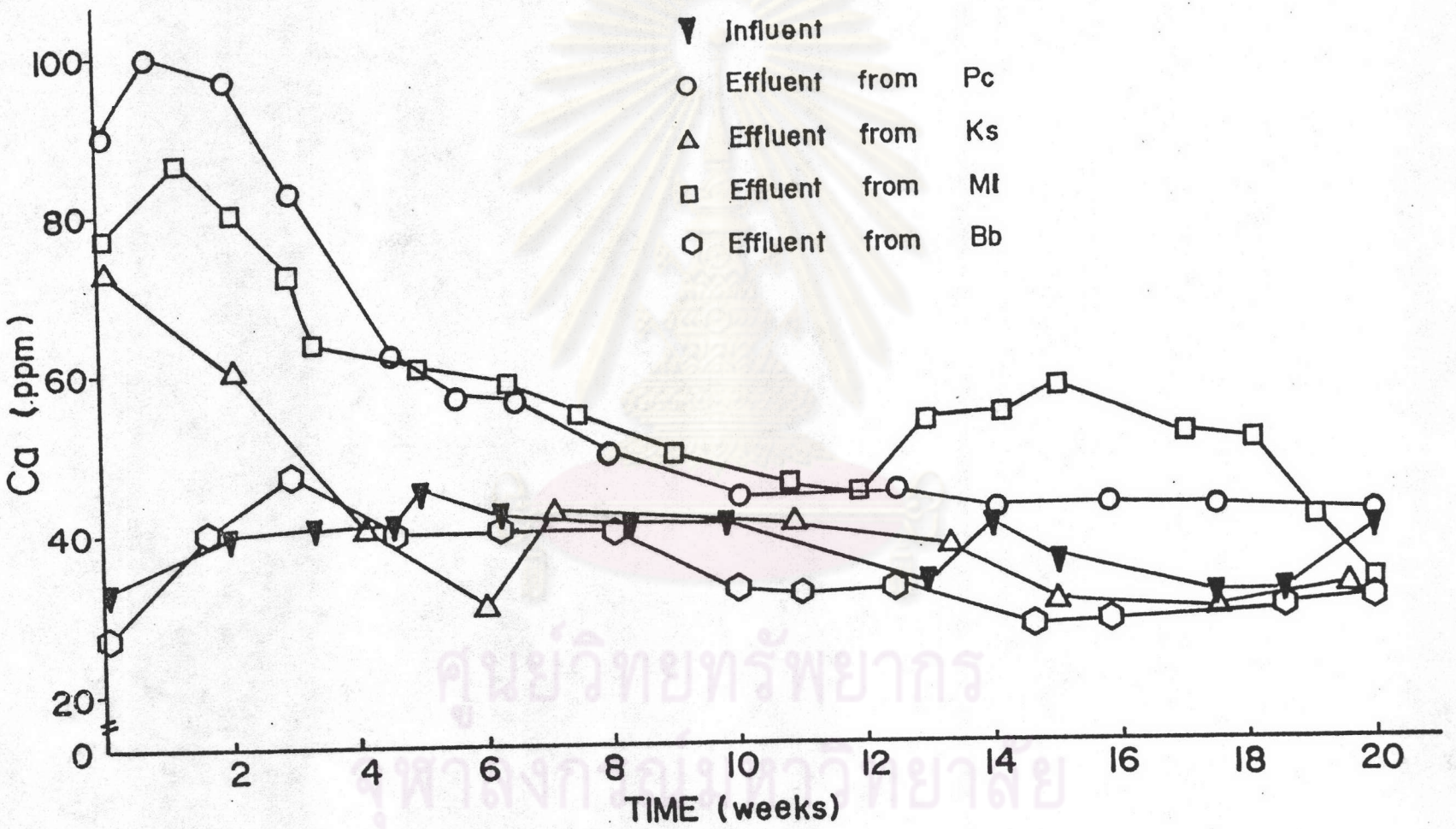

Figure 4.12 Total Ca in the influent and effluent from soils

4.2.5.6 Ca Content in Soil

The amounts of exchangeable Ca in the four tested soil series before and after treatment of wastewater are shown in **Figure 4.13** and **Appendix F.2-F.3.** Exception in Ban Bung series, exchangeable Ca content in all sections (A-G) of all treated-soil series were higher than their content in the same untreated-soil series, i.e., Pak Chong, Khamphaeng Saen and Muak Lek series. However, the total amounts of their content were not much, about 1.24-1.72 times. On the other hand, exchangeable Ca contents in section A-E of Ban Bung soil series were lower than their contents in the same sections of the same untreated-soil series. The remaining sections (F and G), their content in treated-soil were higher than untreated soil.

4.2.5.7 Mg Content in Influent and Effluent

The amounts of Mg in the influent or wastewater and in the effluent from Pak Chong,Khamphaeng Saen, Muak Lek and Ban Bung soil series are shown in **Figure 4.14** and **Appendix E.1-E.5.** Their content in 2 of 4 effluent, i.e., Muak Lek and Ban Bung soil series, were lower than Mg content except from Pak Chong effluent, its content was firstly higher than in the influent, about three weeks after adding the wastewater. Contrary, Mg content from Khamphaeng Saen effluent was higher than its content in the influent.

4.2.5.8 Mg Content in Soil

The total quantities of Mg in four-tested soil series before and after passing of wastewater are shown in **Figure 4.15** and **Appendix F.2-F.3).** After wastewater treatment, Mg content in all sections (A-G) of three soil series, i.e., Pak Chong, Muak Lek

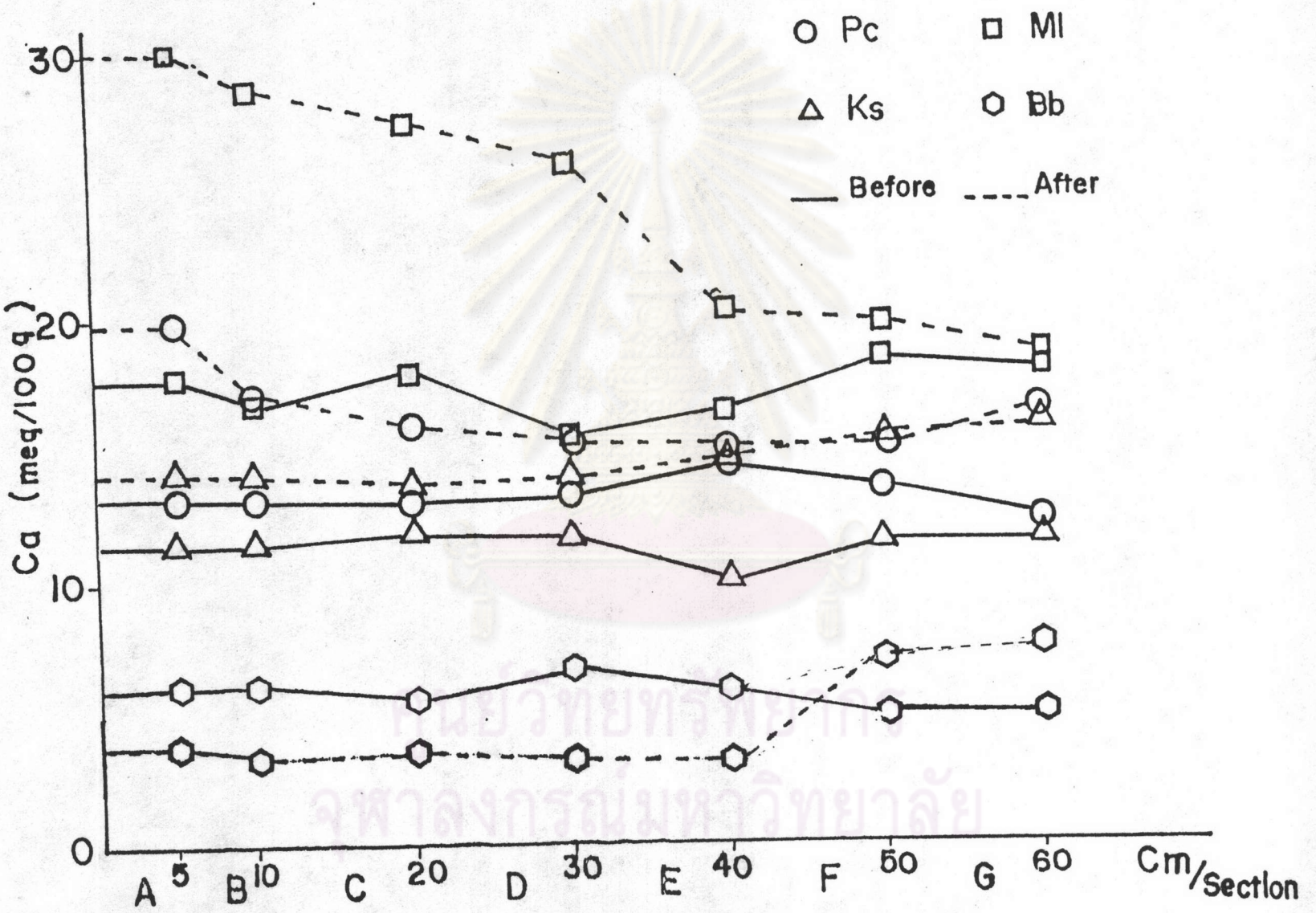

Figure 4.13 Exchangeable Ca of the soil before and after passing with wastewater

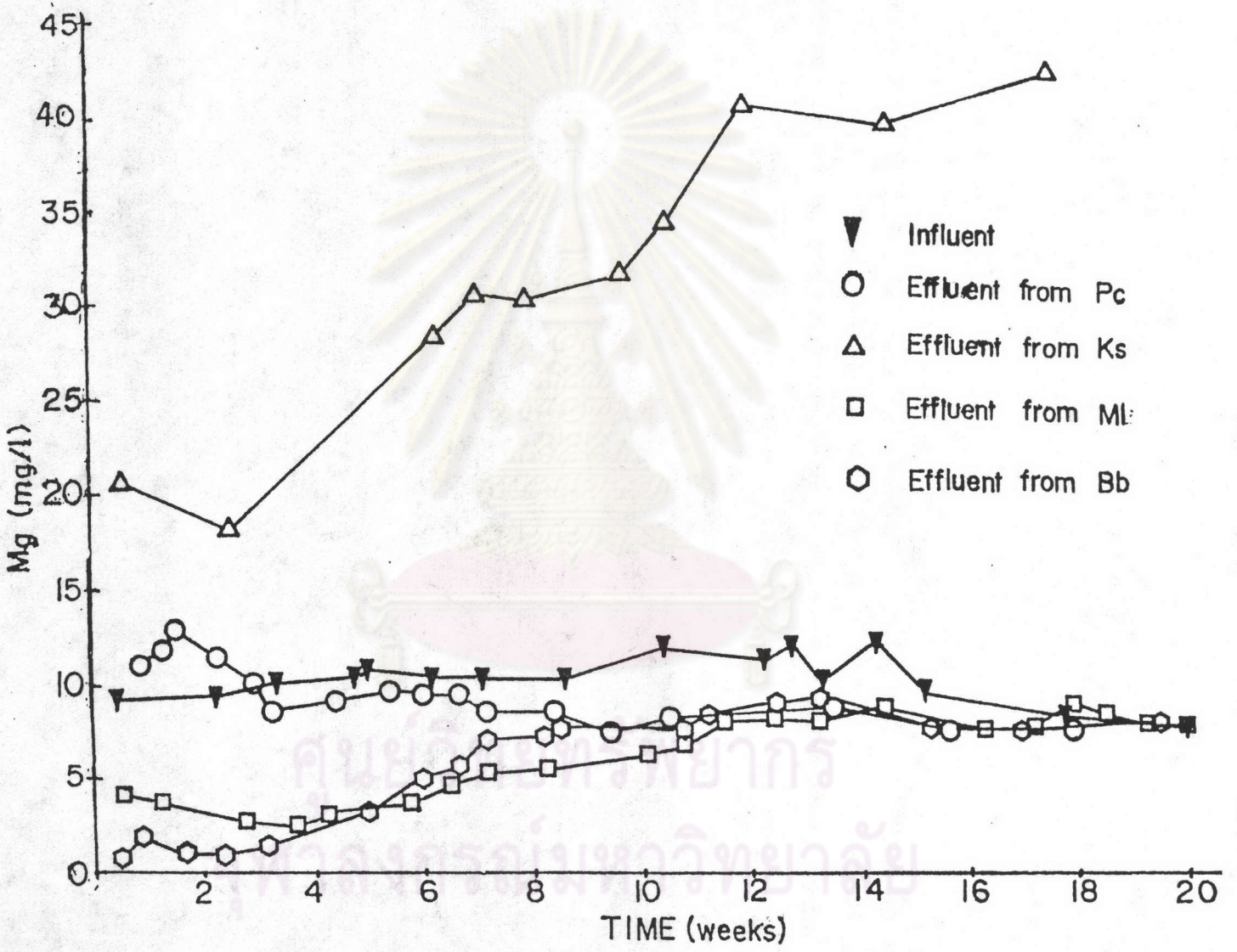

Figure 4.14 Total Mg in the influent and effluent from soils

and Ban Bung, were higher than their content in the same untreatd-soil series. Comparing with other soil series, it found that the concentrations of Mg in Ban Bung soil series before and after wastewater treatment were quite small, i.e., Ø.Ø7 and Ø.6 meq/1ØØg, respectively. It means that the accumulation of Mg in different soil sections of Ban Bung soil series seems to be similar. The trends of Mg content in Muak Lek and Pak Chong soil series were also similar to its content in Ban Bung, but the accumulation of Mg content in Khamphaeng Saen soil series was slightly decreased in soil sections A-D of treated soil but was sharply decreased in the remaining soil sections (E-G).

4.2.6 Anion Content

4.2.6.1 SO_4 and Cl Content in Influent and Effluent

The concentration of SO_4 in the influent and in the effluent from four-tested soil series are shown in **Figure 4.16** and **Appendix E.1-E.5.** Their content from all effluent were lower than its content in the wastewater but varied widely. Their content in the effluent from Ban Bung and Pak Chong soil series were remarkedly decreased within six weeks. After that time its content from Pak Chong effluent was rather low (about Ø.9 mg/l) until the end of the experiment, whereas SO_4 content from Ban Bung effluent was varied all the time. Anyway, the concentration of SO_4 from Khamphaeng Saen effluent was gradually decreased in almost the same ratio.

The concentration of Cl ions in the influent and from Pak Chong, Khamphaeng Saen, Muak Lek and Ban Bung effluent are shown in **Figure 4.17** and **Appendix E.1-E.5.** Originally, its content in the influent was quite varied. After adding of wastewater, Cl content in all effluent were lower than in the influent or wastewater, except from Khamphaeng Saen effluent which

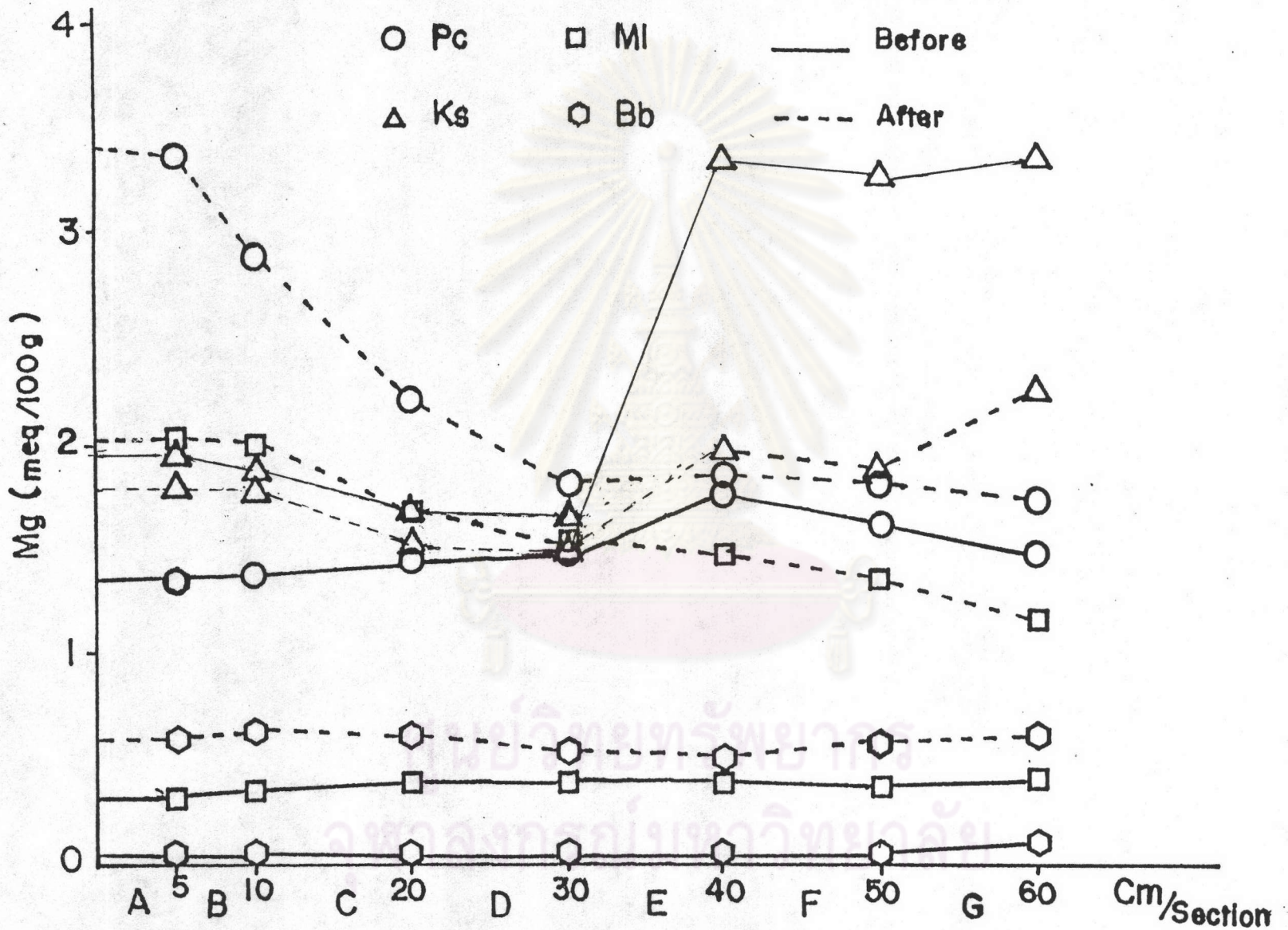

Figure 4.15 Exchangeable Mg of the soil before and after passing with wastewater

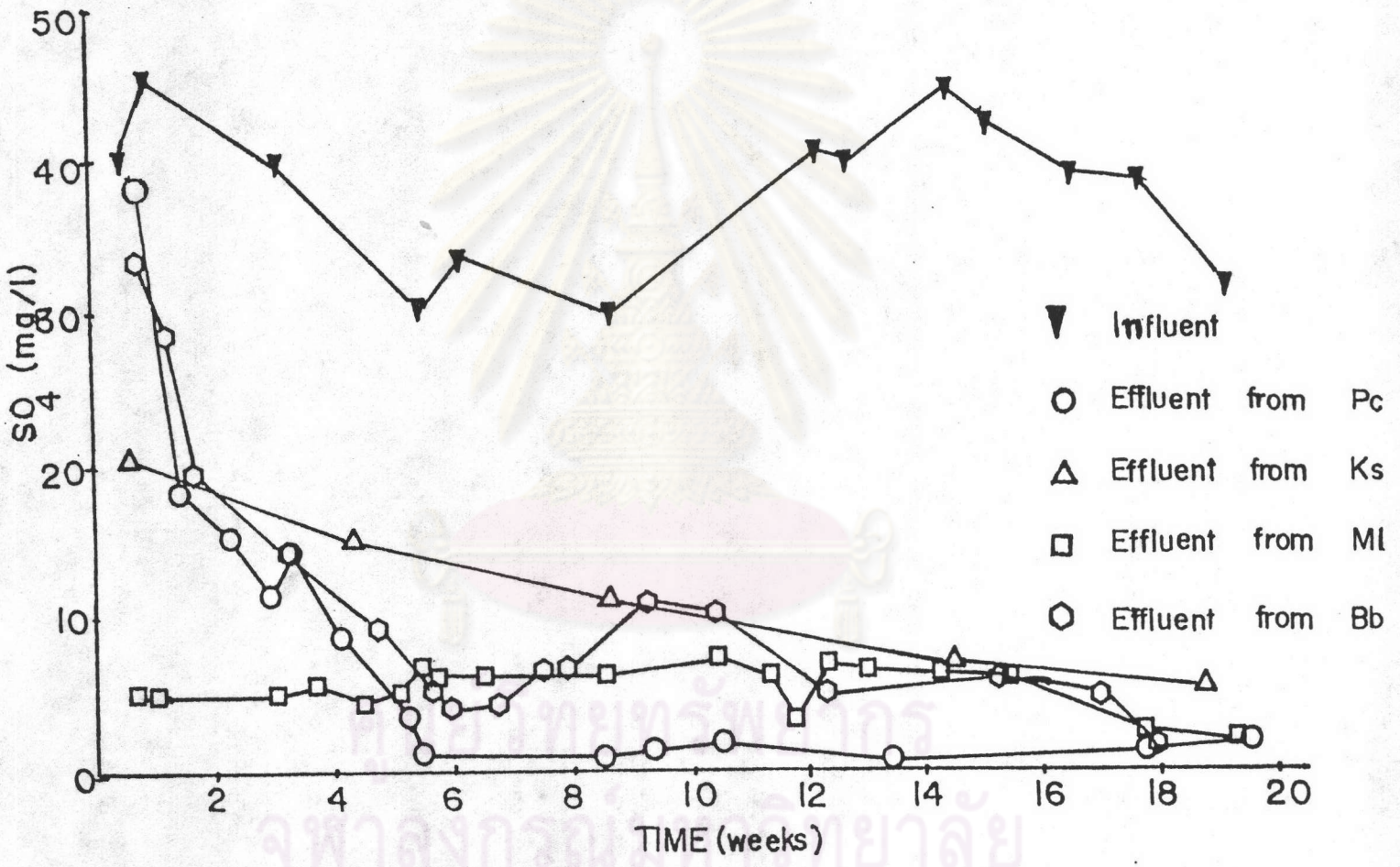

Figure 4.16 Soluble SO_4 in the influent and effluent from soils

its content in the first 2 weeks were markedly higher than the original one, but after that time, its content was lower than Cl content in the wastewater.

4.2.6.2 SO_4 and Cl Content in Soil

SO_4 content in four tested-soil series before and after wastewater treatment are shown in **Figure 4.18** and **Appendix F.2-F.3.** Their content in all sections (A-G) of all untreated-soil series were low and almost be equal or in narrow range (0.02-0.03 meq/100g). After wastewater passing through, SO_4 concentrations in all soil sections of all soil series were higher than the initial concentration. Their content in soil sections A-D of Pak Chong, Muak Lek and Ban Bung soil series were markedly increased and then were gradually decreased in the remaining soil section (D-G). High degree of SO_4 accumulation occured in soil section A-C of those three tested-soil series. SO_4 content in all sections of Khamphaeng Saen soil series were gradually increased.

The total amounts of Cl ions in four-tested soil series before and after passing of wastewater are presented in **Figure 4.19** and **Appendix F.2-F.3.** Original concentrations of Cl ions in Ban Bung and Pak Chong soil series (0.02-0.03 meq/100g) were lower than their concentrations in Khamphaeng Saen and Muak Lek soil series (0.05-0.09 meq/100g), but all were rather constant. After wastewater treatment, their contents in all sections of all soil series were higher than the original ones, but varied widely. Cl contents in Ban Bung and Khamphaeng Saen soil series were gradually increased from section A-G, whereas its content in Muak Lek soil series was sharply increased in soil section B and C, then markedly decreased in section D and increased again in the remaining sections (E-G). In contrast, its content in Pak Chong soil series was gradually increased from

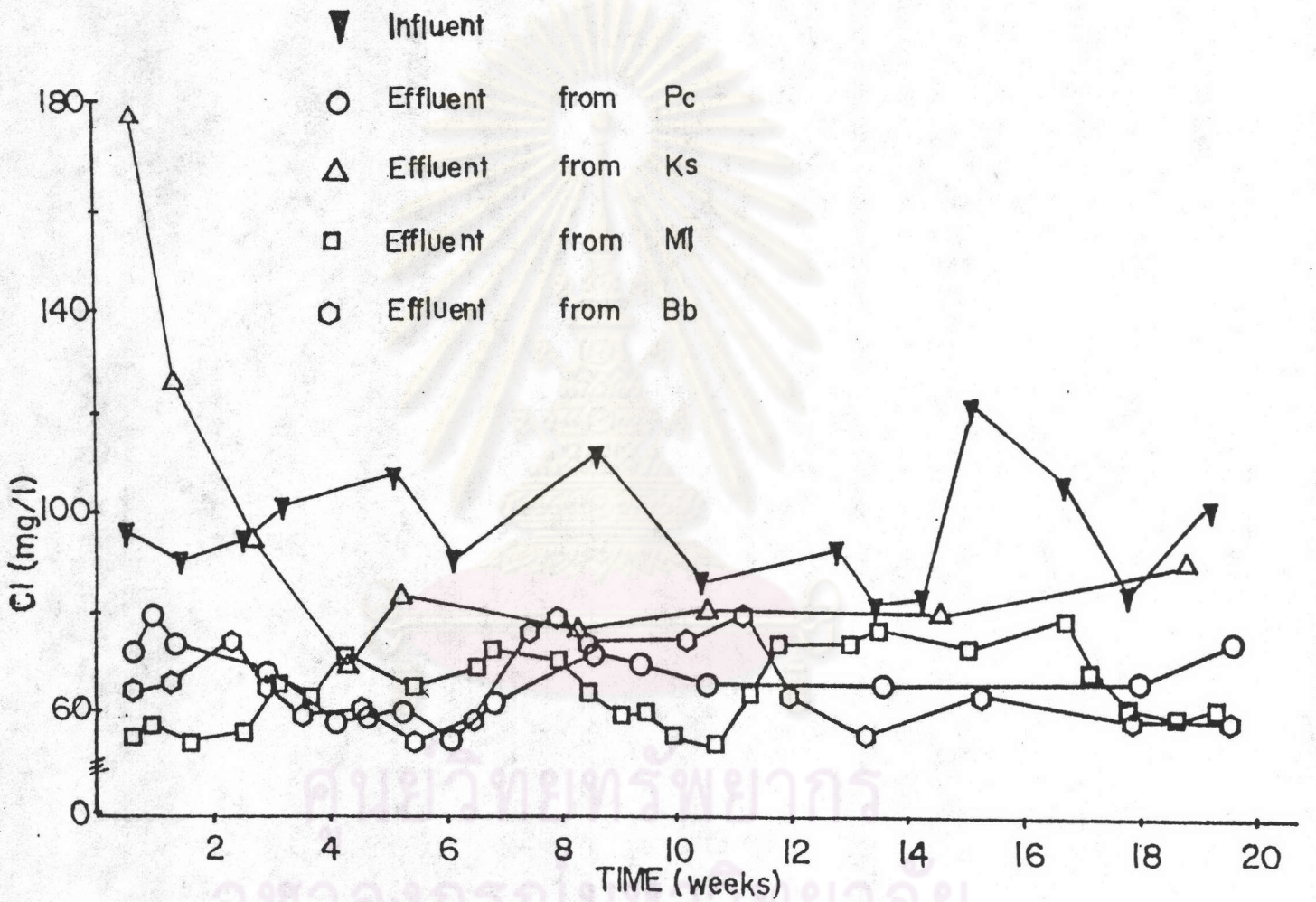

Figure 4.17 Soluble Cl in the influent and effluent from soils

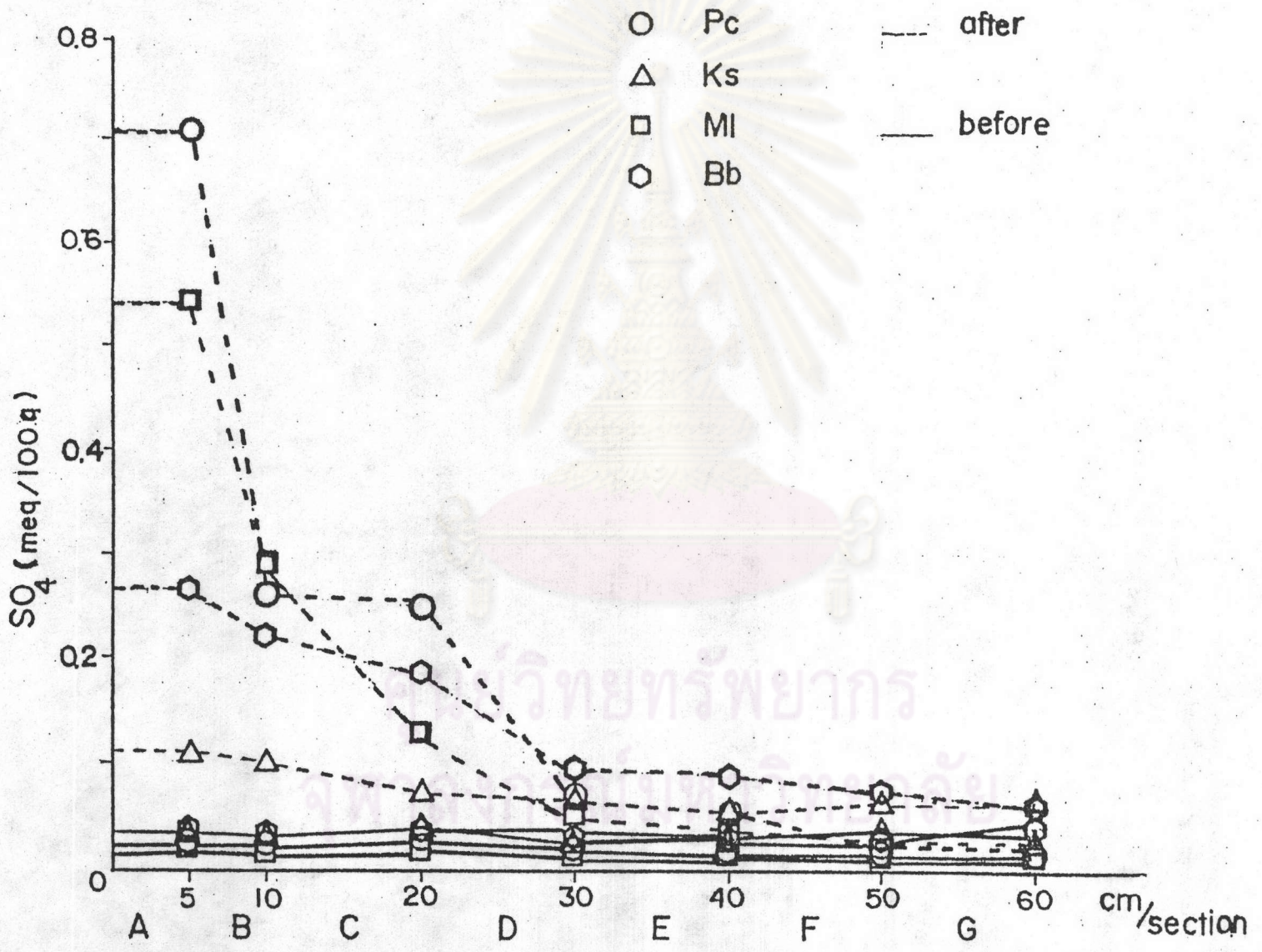

Figure 4.18 Soluble SO_4 of the soil before and after passing with wastewater

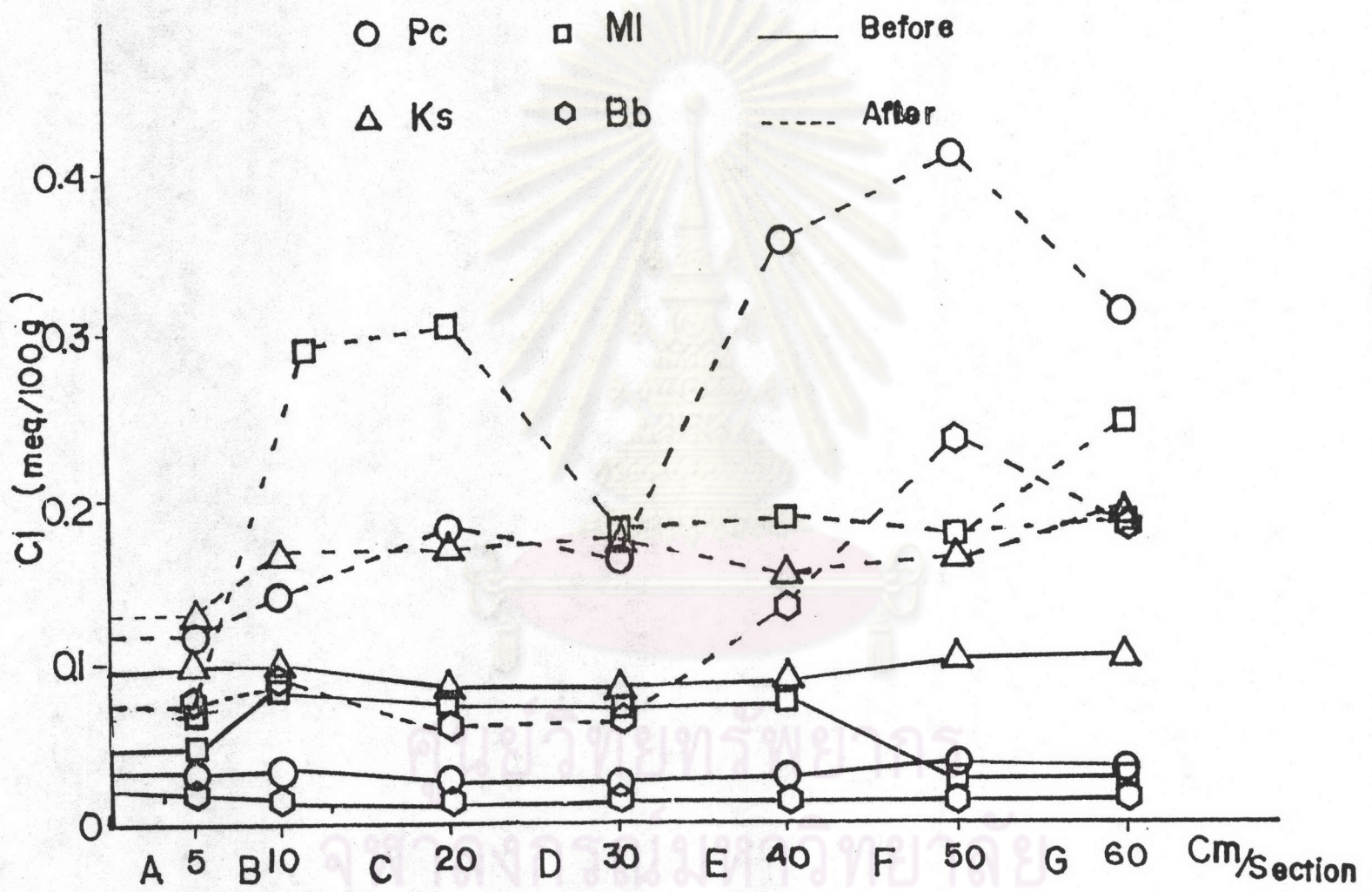

Figure 4.19 Soluble Cl in the soil before and after passing with wastewater

sections A-D, and then markedly increased in sections E-G.

4.2.7 Soil Organic Carbon Content

The total amount of organic carbon in four-tested soil series before and after wastewater treatment are shown in **Figure 4.20** and **Appendix F.2-F.3.** Organic carbon concentrations in different soil series were varied depending on their fertility. The least one was detected in Ban Bung soil series, the higher ones were in Khamphaeng Saen and Muak Lek soil series, respectively, and the highest was in Pak Chong soil series. After passing of wastewater, through organic carbon contents in all soil sections (A-G) of all soil series were higher than the initial levels in each of untreated soils. In Ban Bung and Muak Lek soil series, the increment of organic carbon in treated soil was quite low, i.e., from 0.13% to 0.19% or 1.44 times in Ban Bung soil series and 0.37% to 0.54% or 1.45 times in Muak Lek soil series. In Khamphaeng Saen soil series, their contents in section A, F and G were quite high, comparing with sections B-D, it found that organic carbon contents were narrow range (1.03 to 1.07%) or nearly equal. Similarly, the highest concentration of organic carbon was found in treated Pak Chong soil series, that was from 0.96% to 2.36% or 2.45 times. However, the organic carbon increased extensively in Pak Chong and Khamphaeng Saen soil series.

4.2.8 COD Loading

COD loading of wastewater and effluents from four tested-soil series are presented in **Figure 4.21** and **Appendix E.1-E.5.** The average value of COD loading of the influent was 601.99 mg/l. Their values of all effluents were lower than COD loading in the influent, i.e., about 90% decreasing. However, the wastewater had been settled down inside the lower ends of the

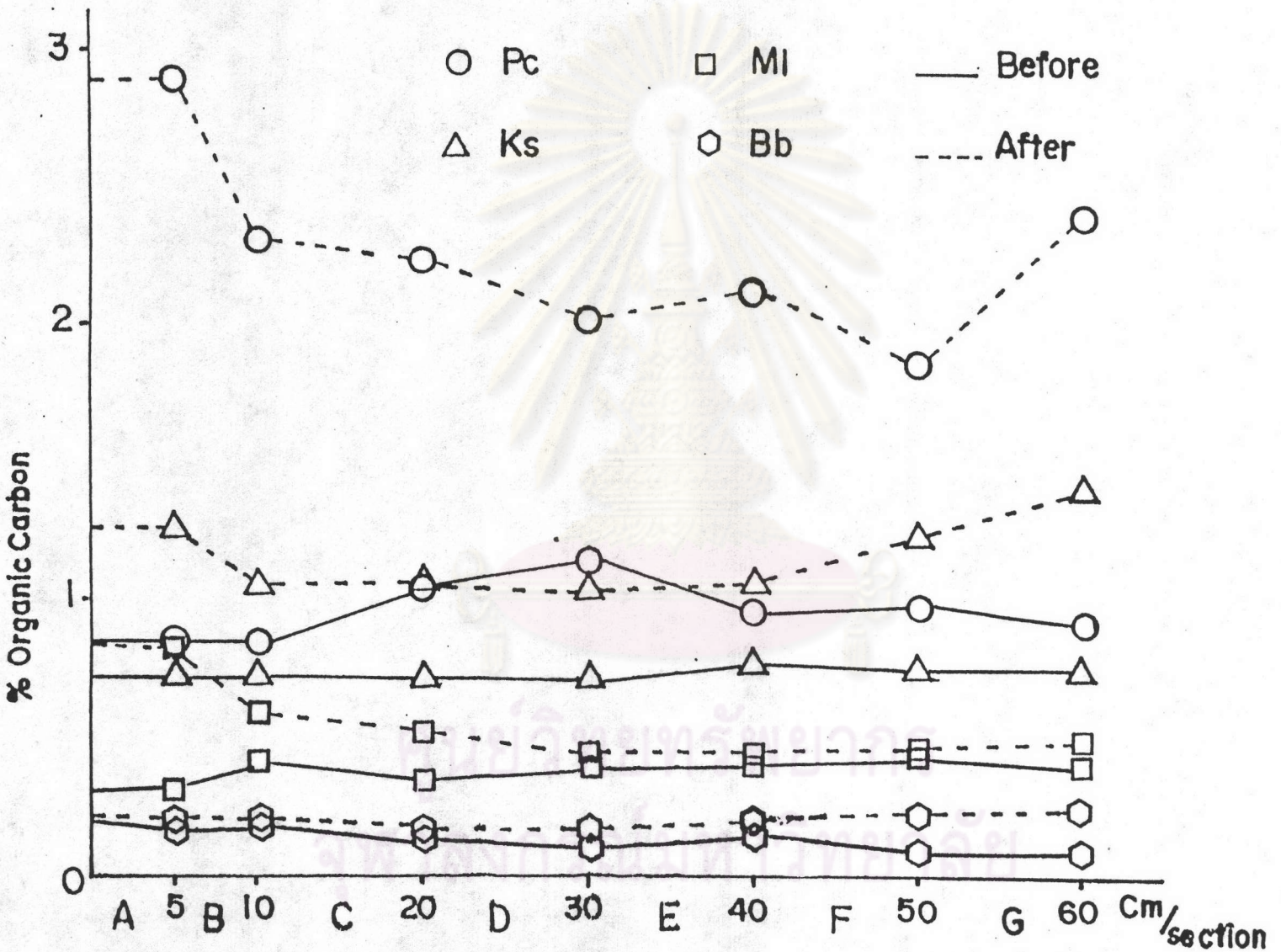

Figure 4.20 Organic carbon of the soil before and after passing with wastewater

vertical columns of the influent. Thus, the initial COD loading before perculating through the soil column was less than original COD loading of the wastewater. It was found that about 30% of its loading was decreased **(Appendix G)**.

4.2.9 CEC Content

The amounts of CEC in four tested-soil series before and after treatment of wastewater are shown in **Figure 4.22** and **Appendix F.2-F.3.** The ground levels of CEC in each untreated soil were different and seemed to be equal in all sections (A-G) of the same soil series. The highest was occured in Pak Chong soil series, and the least one was in Ban Bung soil series. In Muak Lek and Khamphaeng Sean soil series, their ground level were almost equal, i.e., 8.48 and 8.50 meq/100g, respectively. After passing of wastewater, CEC levels of all treated soil series were slightly higher than their ground levels.

4.2.10 Fecal Coliform Content

4.2.10.1 E.coli Content in Influent and Effluents

Viable counts of E. coli in influent and in effluents from four-tested soil series are shown in **Figure 4.23** and **Appendix F.2-F.3.** About 1.65×10^{6} cells/ml of E. coli could be detected in the influent. All soil series could eliminate E. coli from the influent and made the effluents clear of the microbe at the different periods of time, i.e., 7, 14, 15 and 17 weeks for Khamphaeng Saen, Pak Chong, Muak Lek and Ban Bung soil series, respectively. It was found that clearance rate of E. coli in Muak Lek and Ban Bung soil series seems to be similar and slower than Pak Chong and Khamphaeng Saen soil series.

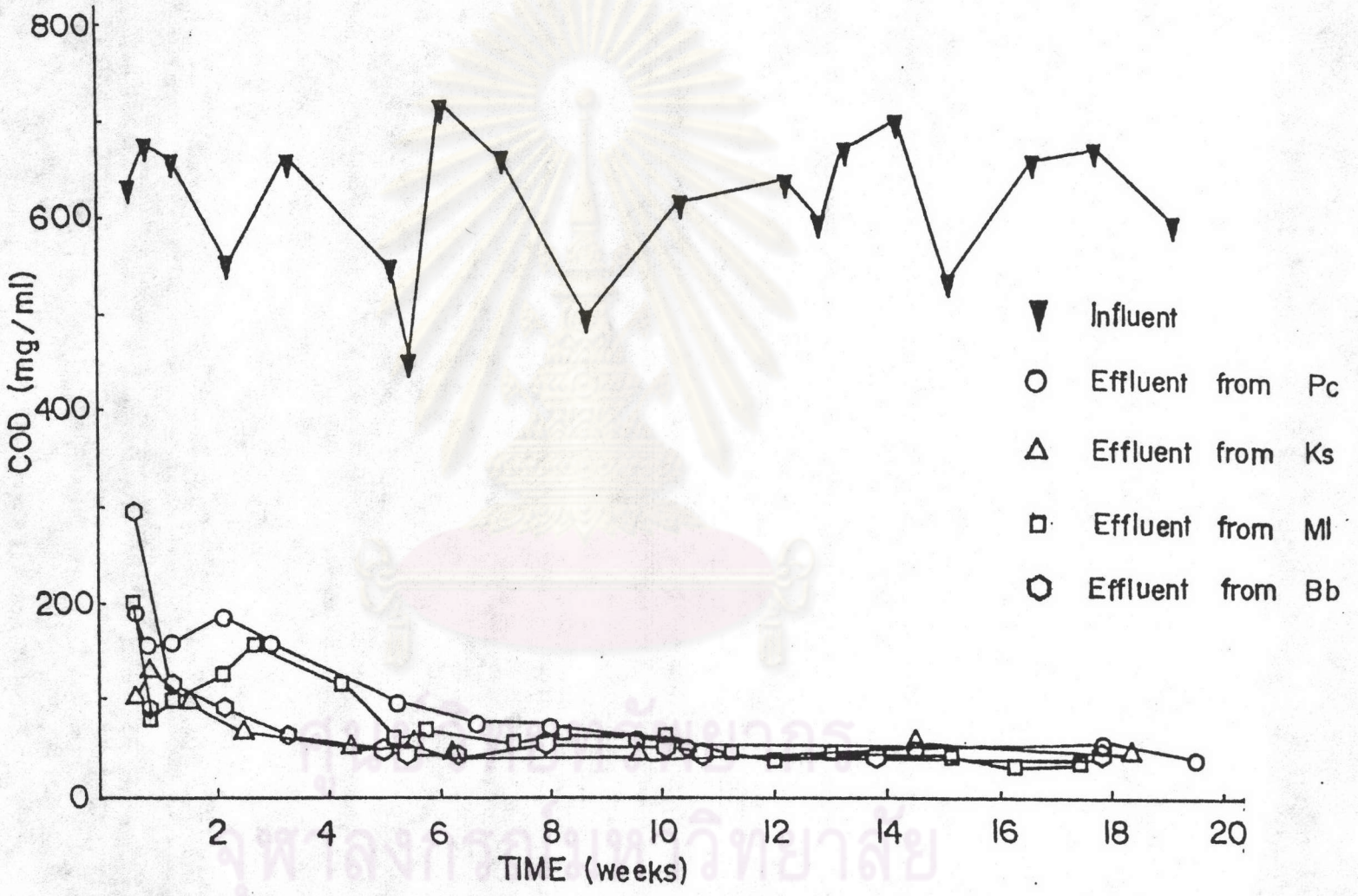

Figure 4.21 COD in the influent and effluent from soils

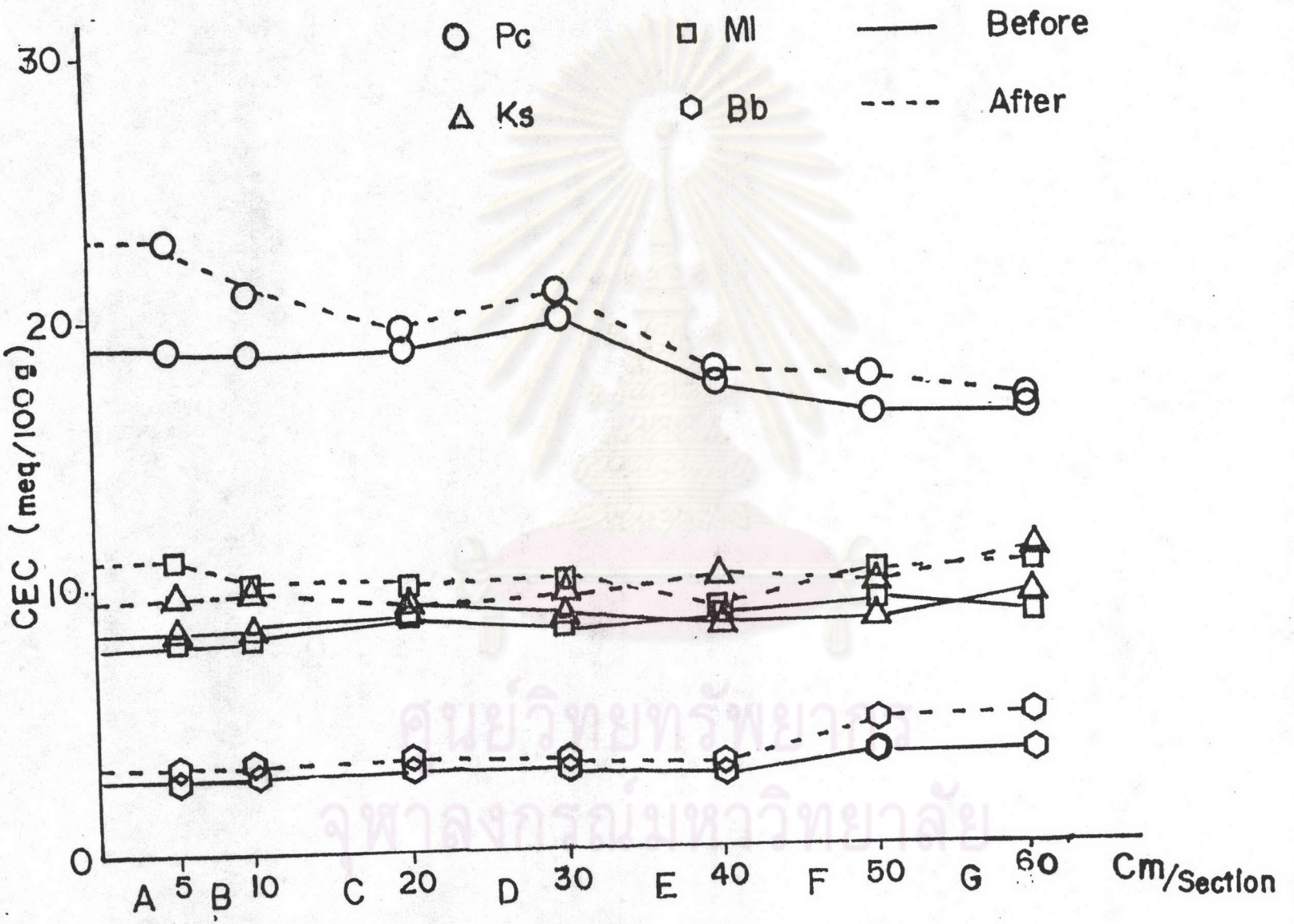

Figure 4.22 CEC of the soil before and after passing with wastewater

4.2.10.2 Fecal Coliform in Soil

Viable counts of E. coli in soil sections (A-G) of four tested soil series are presented in **Figure 4.24** and **Appendix F.2-F.3.** In all untreated soil, E. coli could not be detected or no contamination of fecal coliform. E. coli could grow in all sections (A-G) of all wastewater treated soils, and the highest number viable counts of each soil series could be found in section A, then similarly declined from sections B-G, and the least number of E. coli occured in section F and/or G of all treated soils. In section A of the treated Khamphaeng Saen soil series, E. coli could be detected in the highest quantity and declined sharply from sections B-D. This evidence also occured in the remaining treated soil series and from section E-G of all treated soils, and the organism could be found in rather small number(37-270 col/g of soil).

4.3 Changes in Some Characteristics of Effluent

4.3.1 Pak Chong Effluent

Some characteristics of influent or domestic wastewater and Pak Chong effluent are shown in **Figure 4.25-4.26.** After 20-week passing of wastewater through Pak Chong soil column (932 ml daily in average), all tested parameters of the effluent seemed to differ from those of the influent. The mean value of pH was slightly higher. Contents of 8 of 11 parameters in the Pak Chong effluent were lower than their contents in the influent, i.e., Na, Mg, Cl, COD, NH_4-N, SO_4, and orthophosphate. It was found that, Na content, at the week 20, was changed from lower to higher than influent. Also, the mean percentages of Ca and K were higher than their influent.

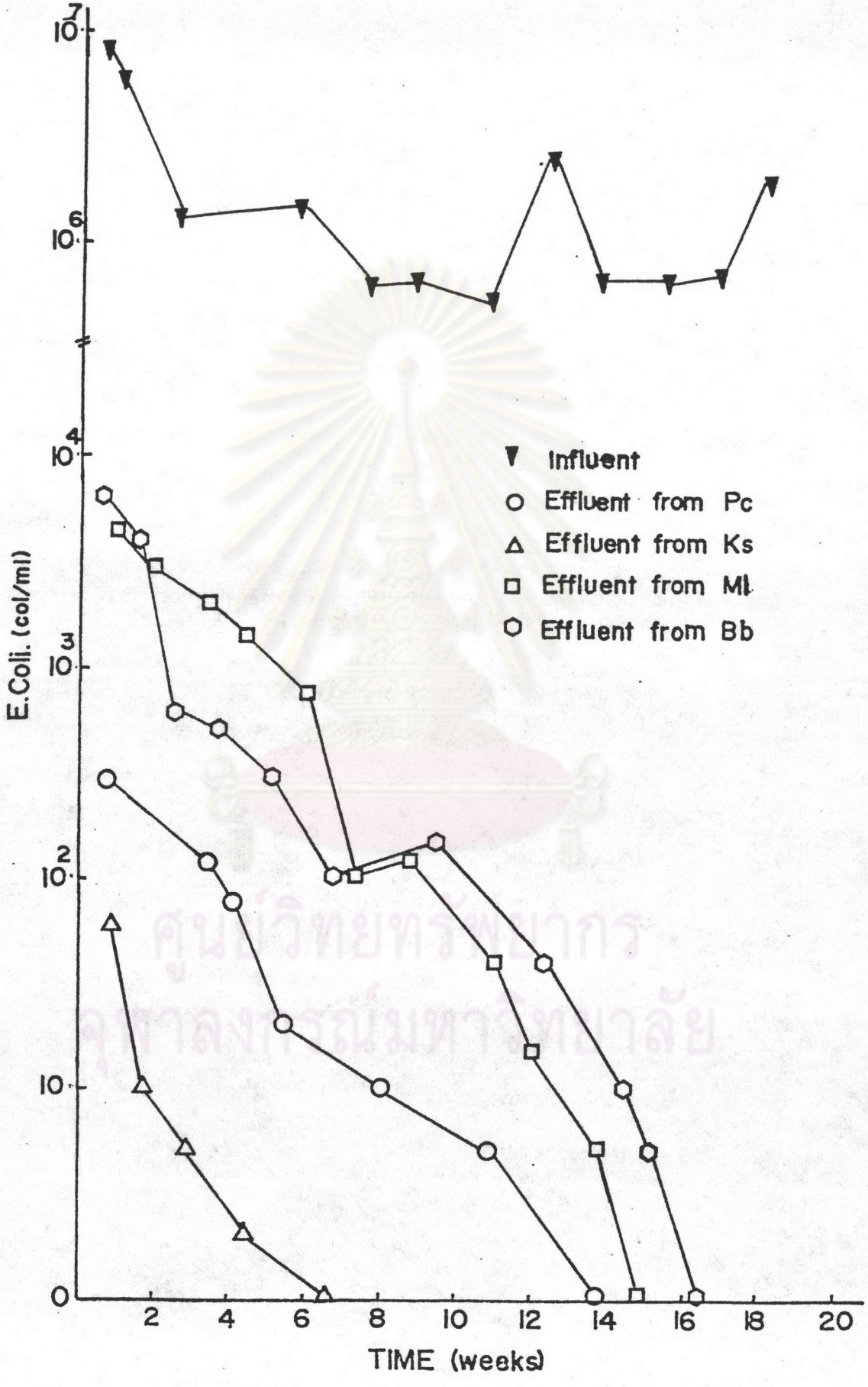

Figure 4.23 E. coli in the influent and effluent from soils

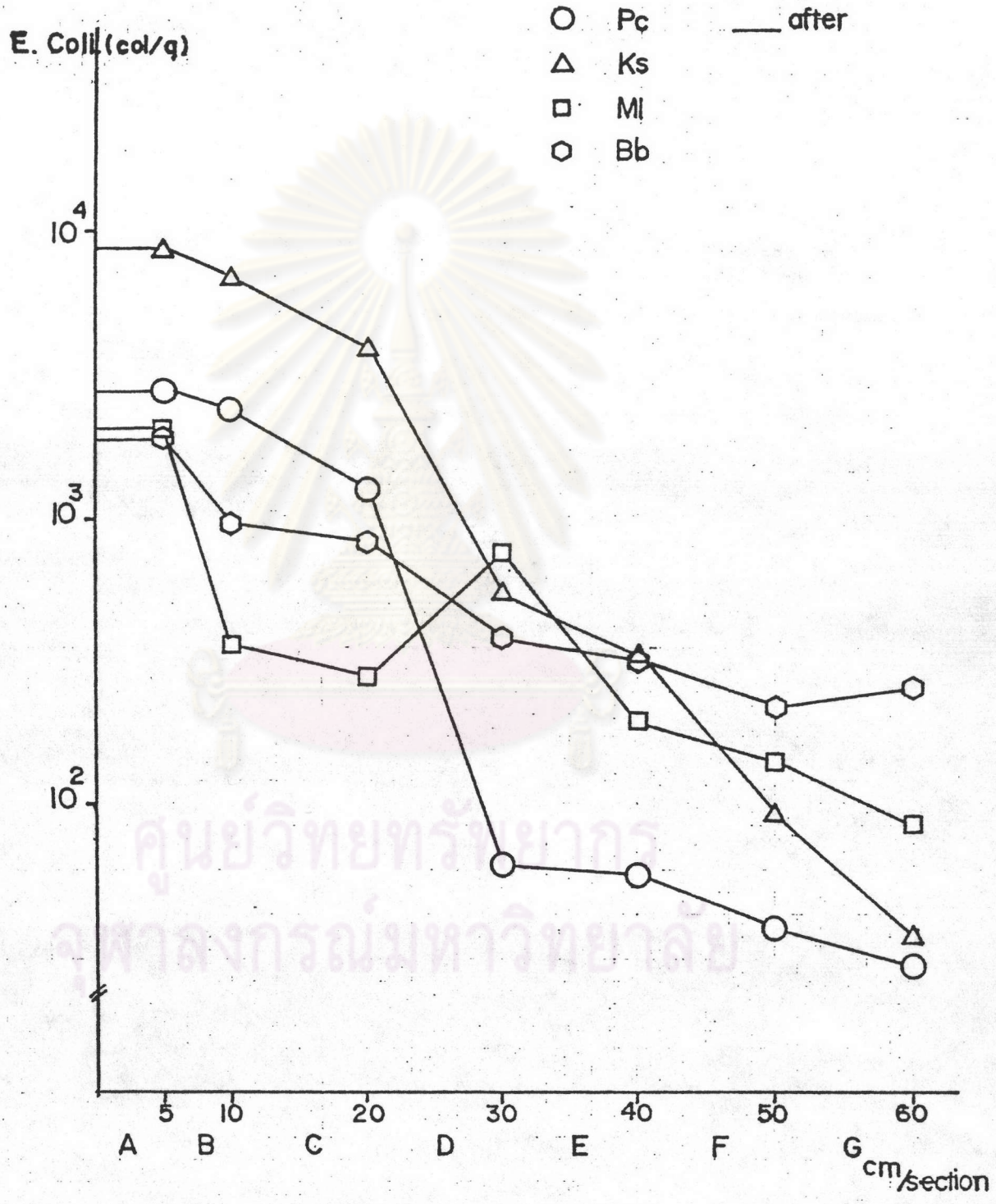

Figure 4.24 E.coli of the soil before and after passing with wastewater

4.3.2 Khamphaeng Saen Effluent

Figure 4.25 and 4.27 showed the chemical and biological properties of influent and Khamphaeng Saen effluent. The average amount of added wastewater per day into Khamphaeng Saen soil column was 97 ml. After 20-week passing of wastewater NO_3-N, orthophosphate and E.coli could not be found and lower than influent. Contents of NH_4-N, COD, SO_4 , Ca and Cl were reduced. The contents of Na were sharply decreased with in 1-4 weeks, and then be gradually increased until higher than influent. For all the period of experiment, contents of K and Mg, were clearly higher than those in the influent. The pH of the Khamphaeng Saen effluent was slightly increased.

4.3.3 Muak Lek Effluent

The characteristics of Muak Lek effluent and influent are shown in **Figure 4.25 and 4.28.** The average amount of added wastewater per day into Muak Lek soil series are equal to 785 ml. Contents of 8 of 11 parameters in the Muak Lek effluent were lower than their contents in the influent, i.e., SO_4, COD, NH_4-N, orthophosphate, Mg, Cl and Na.pH and Ca content were higher than those in the influent for the period of 20 week, and also the pH of the Muak Lek effluent was slightly increased. While K content was changed from lower to higher in 3-week period. At the week 4, NO_3-N could be detected and its content at the week-20 was 17.82 mg/l. NO_3-N in the influent could not be found. Viable count of E.coli could not found in Muak Lek effuent at week-15.

4.3.4 Ban Bung Effluent

Some characteristics of Ban Bung effluent changed as same as Muak Lek effluent and showed in **Figure 4.25** and **4.29.** The

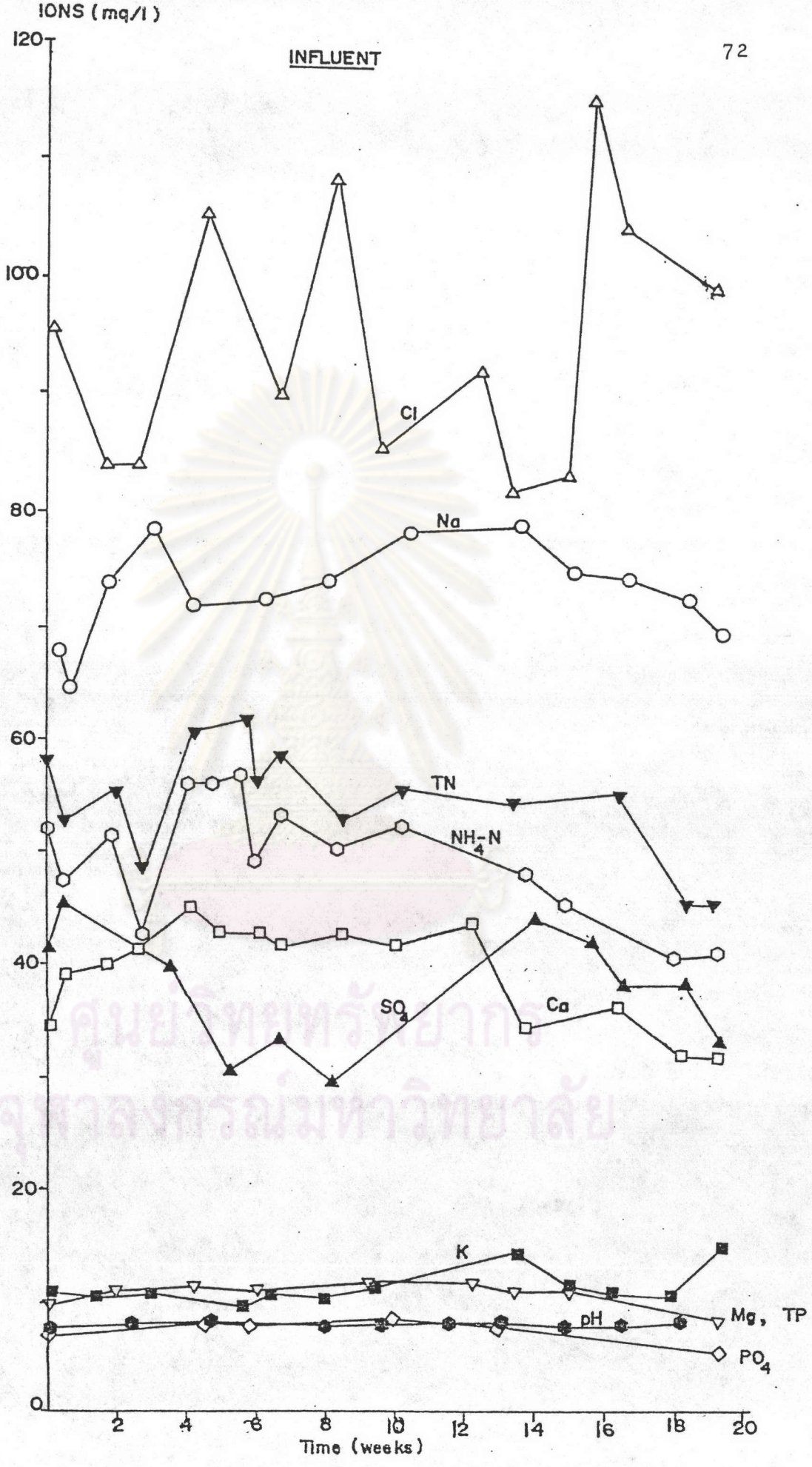

Figure 4.25 Characteristics of the influent

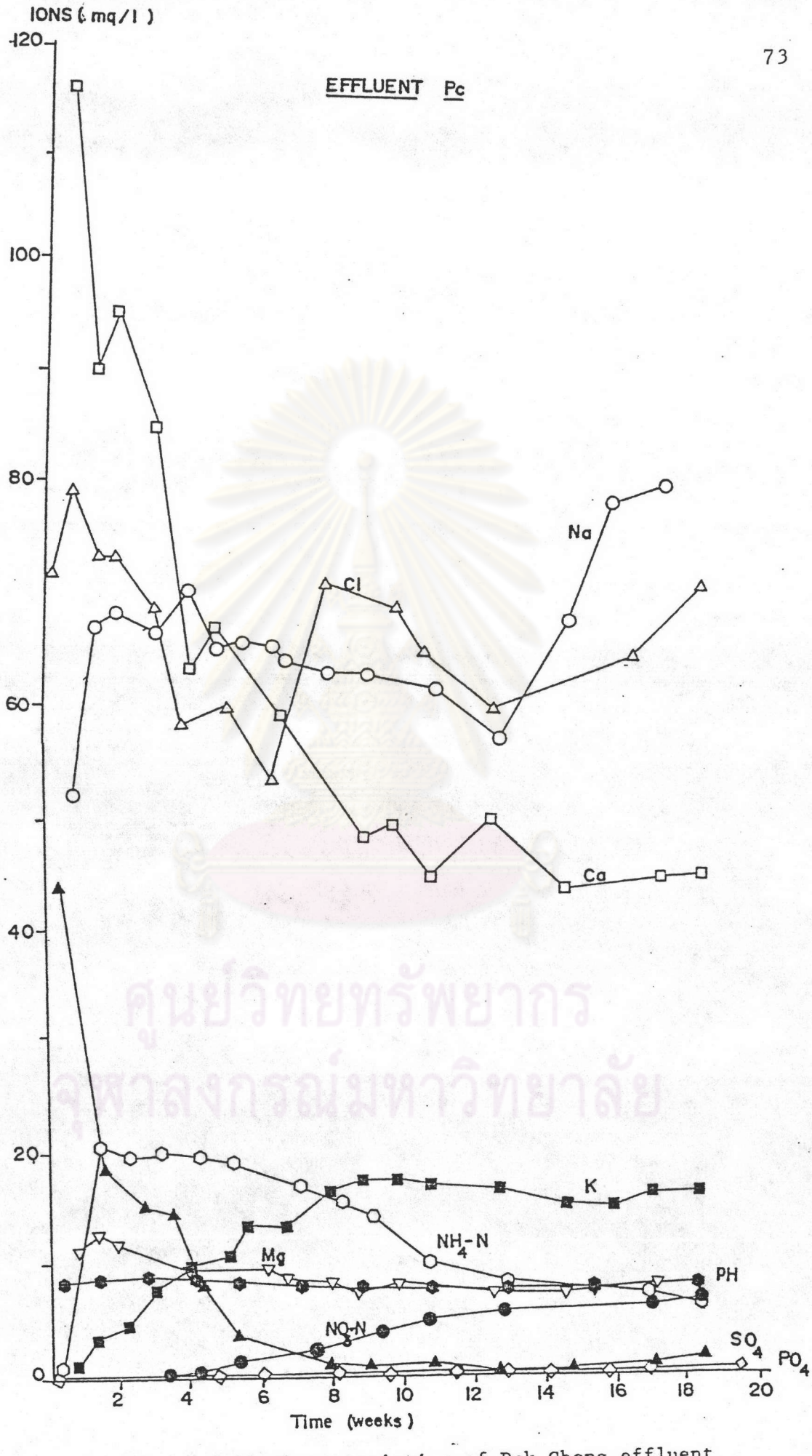

Figure 4.26 Characteristics of Pak Chong effluent

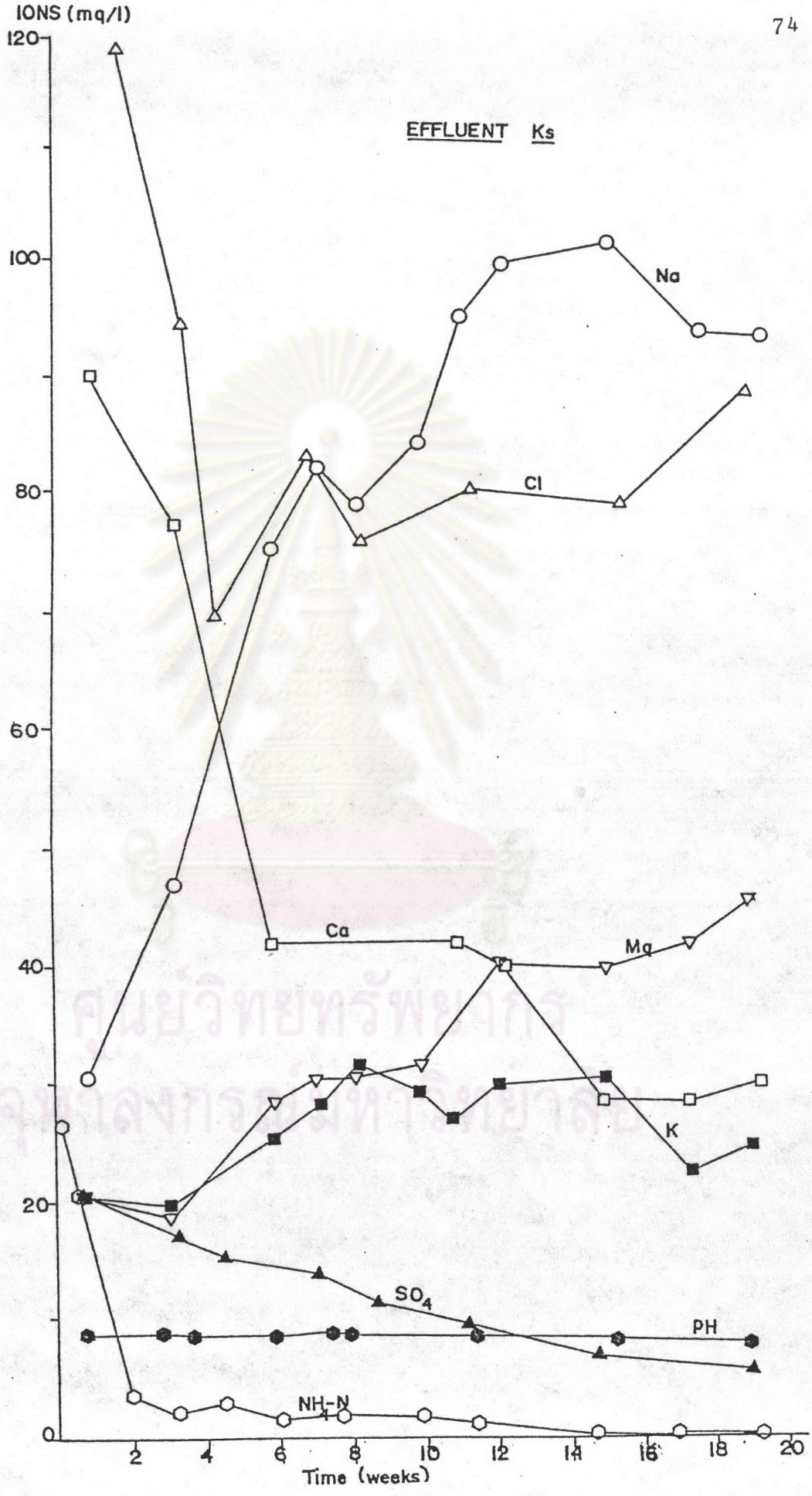

Figure 4.27 Characteristics of Khamphaeng Saen effluent

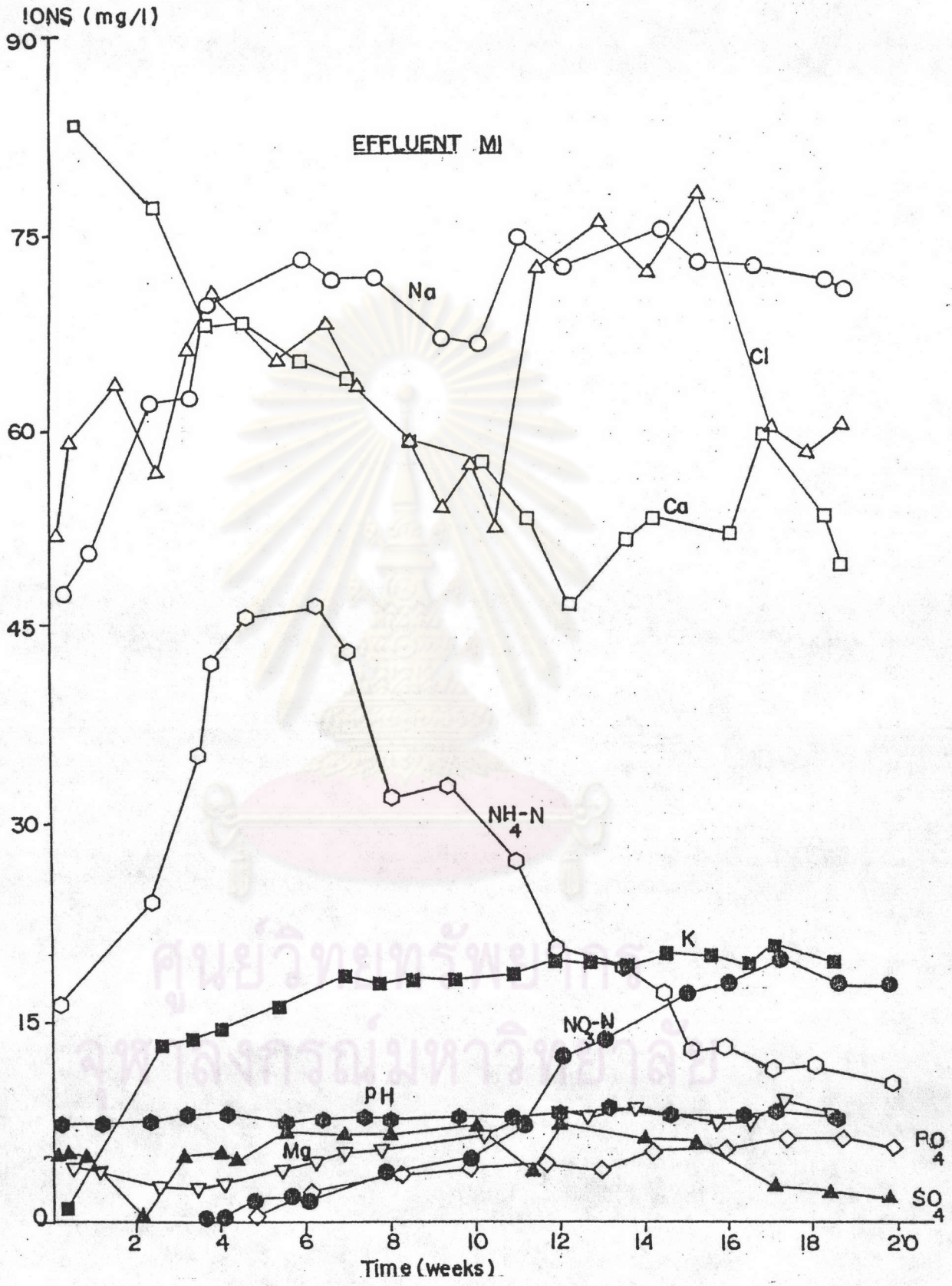

Figure 4.28 Characteristics of Muak Lek effluent

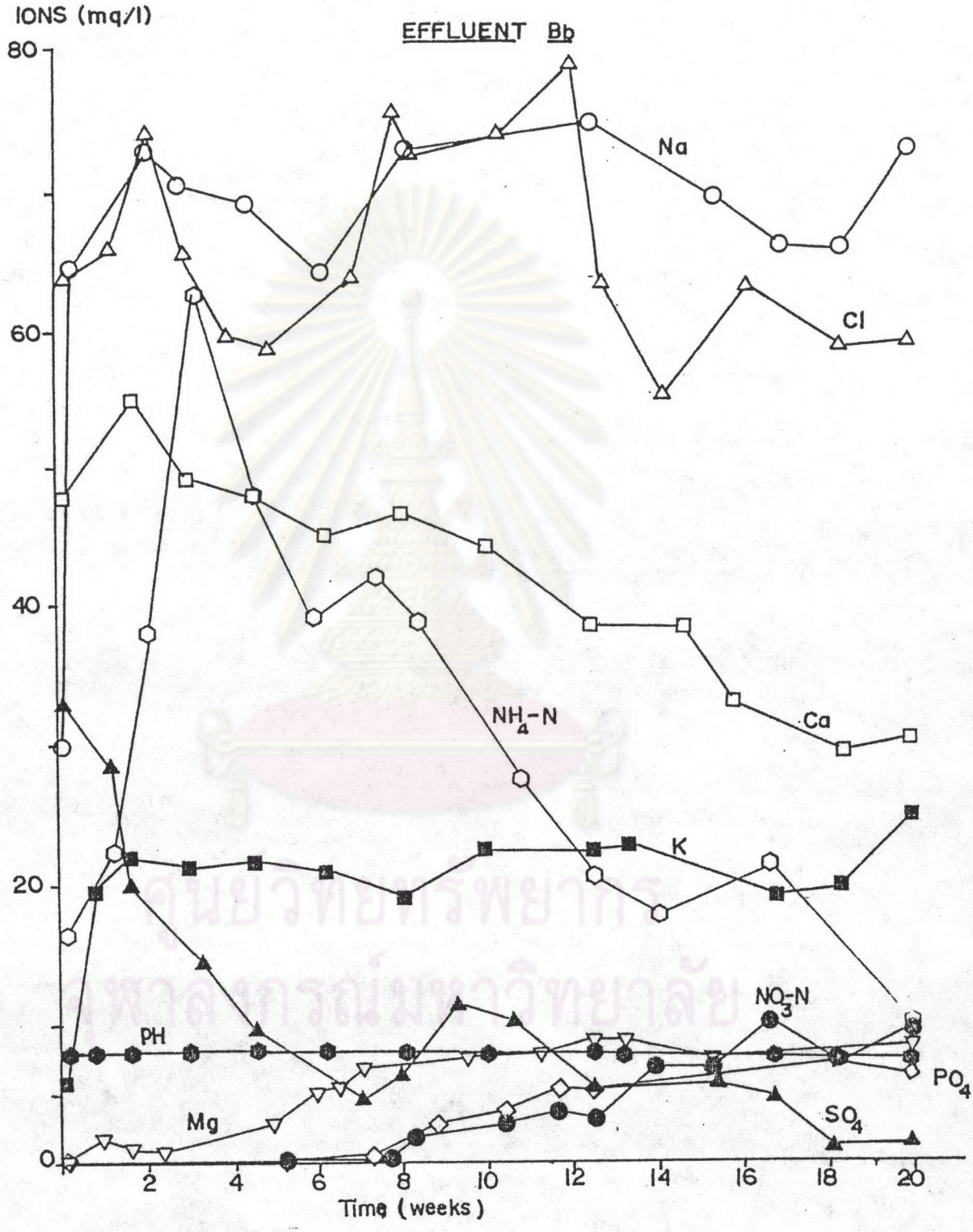

Figure 4.29 Characteristics of Ban Bung effluent

average amount of added wastewater per day into Ban Bung soil series are equal to 1197 ml. NO_3-N could be detected at the week-5 and the content of the week-20 was equal to 8.93 mg/l. SO_4, COD, NH_4-N, PO_4-P, Mg and Cl were lower than their influent and pH and K were higher than those in the influent.

4.4 Changes in Some Characteristics of Soil After Wastewater Treatment

4.4.1 Treated Pak Chong Soil

Some properties of untreated and treated Pak Chong soil were shown in **Figure 4.30-4.31** and **Table 4.4.** The average contents of all treated parameters were increased after passing of wastewater for 20 weeks. The highest concentrations in the treated Pak Chong soil of SO_4, K, total-P, Mg, organic carbon, total-N, Ca and CEC were found in section A (0-5 cm), about 35.5, 8.43, 4.48, 2.5 2.42, 1.69, 1.47 and 1.20 times, respectively. The highest content of other parameters, such as, NH_4-N, NO_3-N, extractable-P and Cl were found in section F (40-50 cm). The average after/before ratio of NH_4-N, Cl and extractable-P, were 130.03, 8.97 and 1.17 times, respectively. NO_3-N and *E. coli* could be detected 0.0014% and $1.3x10^3$ col/g, whereas untreated Pak Chong soil could not be found **(Table 4.4)**.

All treated sections of Pak Chong soil series could be retained all ions types of wastewater and contents of 9 of 14 parameters were highly accumulated at 0-5 cm (section A), i.e., *E.coli*, SO_4, K, total-P, organic C, Mg, total-N, Ca and CEC. Other parameters, i.e., NH_4-N, NO_3-N, Cl and extractable-P were highly accumulated in section F or 40-50 cm. Na was found in section E (30-40 cm). The highest value of pH was found in section B of the column (5-10 cm).

Table 4.3 Changes in some characteristics of Pak Chong soil series in column which had been treated with domestic wastewater for 20 weeks.

characteristics of soil	Average Concentration before	after	A/B ratio (times)	Concentration in soil section after treatment (A-G) highest	lowest
				length(cm)	
pH	6.17	6.50	1.05	B(5-10)	G(50-60)
TKN (%)	0.1437	0.2143	1.49	A(0-5)	C(10-20)
NH_4-N (%)	0.0005	0.0488	130.03	F(40-50)	C(10-20)
NO_3-N (%)	0	0.0014	-	F(40-50)	C(10-20)
Total-P (ppm)	28.0	101.2	3.62	A(0-5)	D(20-30)
Extract-P(ppm)	19.65	23.09	1.17	F(40-50)	A(0-5)
Na (meq/100g)	0.18	0.84	4.63	E(30-40)	B(5-10)
K (meq/100g)	0.09	0.50	5.91	A(0-5)	B(5-10)
Ca (meq/100g)	13.49	16.73	1.24	A(0-5)	E(30-40)
Mg (meq/100g)	1.56	2.31	1.52	A(0-5)	E(30-40)
Cl (meq/100g)	0.03	0.27	8.97	F(40-50)	A(0-5)
SO_4 (meq/100g)	0.02	0.20	9.79	A(0-5)	G(50-60)
Organic C (%)	0.9630	2.368	2.45	A(0-5)	D(20-30)
CEC (meq/100g)	18.07	19.31	1.07	A(0-5)	G(50-60)
E. coli (col/g)	nil	1.03×10^3	-	A(0-5)	G(50-60)

Texture: sand:silt:clay = 15.3:26.7:58.3

A/B ratio = after/before

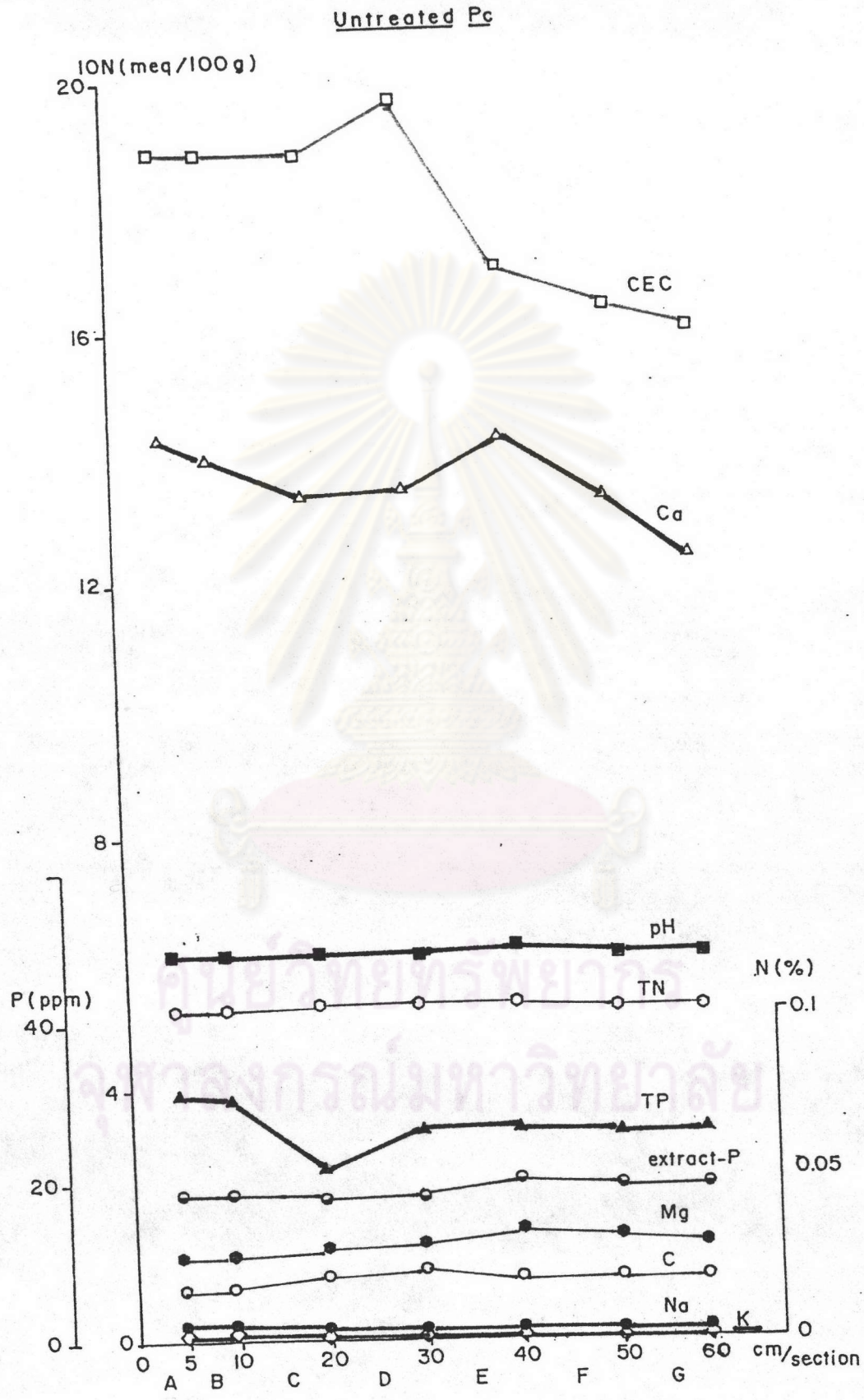

Figure 4.30 Characteristics of untreated Pak Chong soil series

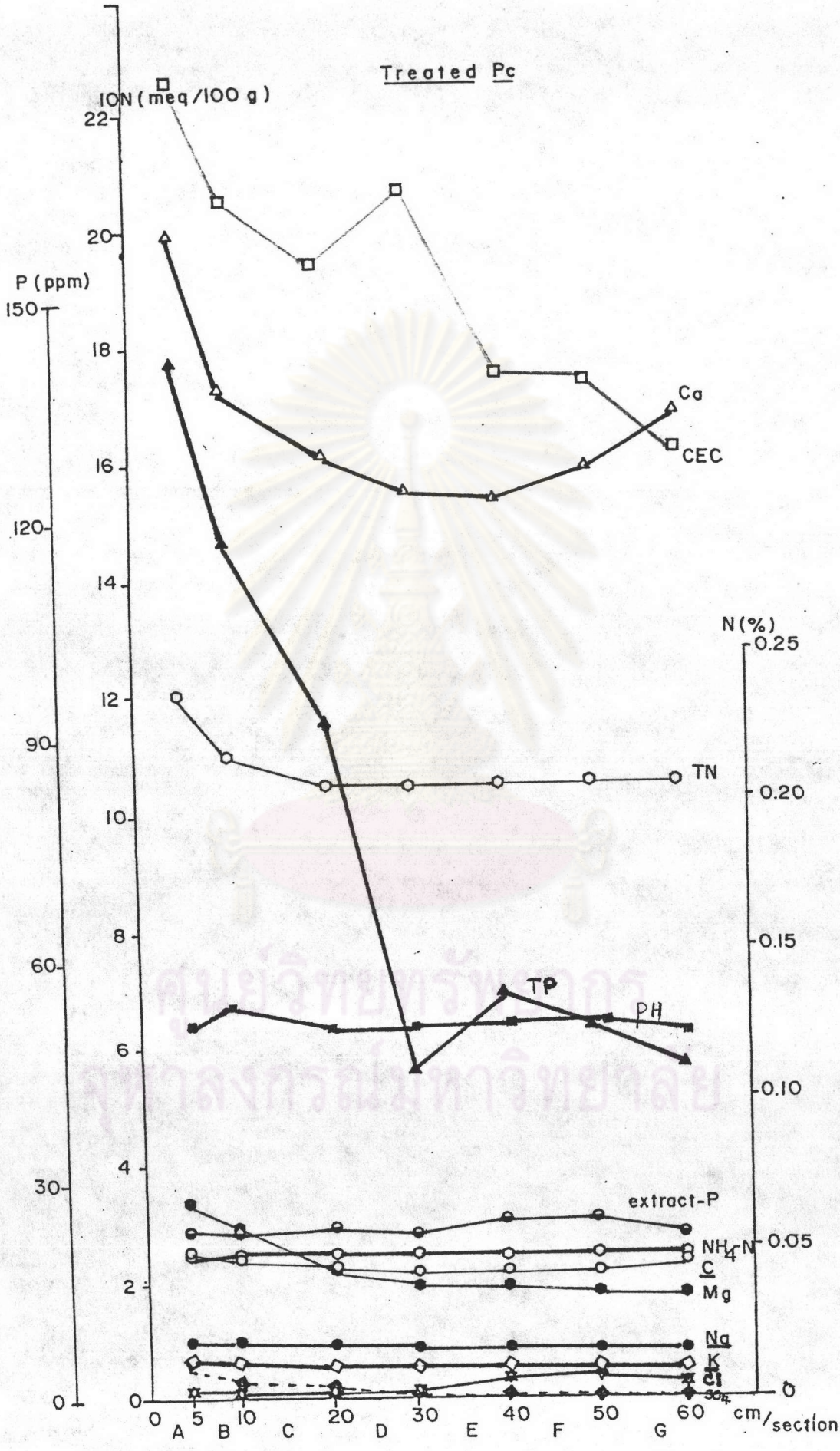

Figure 4.31 Characteristics treated Pak Chong soil series

4.4.2 Treated Khamphaeng Saen Soil

Some characteristics of Khamphaeng Saen soil before and after wastewater treatment are shown in **Figure 4.32-4.33** and **Table 4.5.** Most of them were increased in the treated soil except NO_3-N and Mg. NO_3-N contents of sections B to G were decreased whereas its content in section A was increased 1.1 times, and after/before ratio of Mg was reduced about 1.63 times. The highest contents of 6 of 14 parameters were found in section A (0-5 cm), i.e., SO_4, Na, total-N, K, total-P, extractable-P, and after/before ratio were 2.52, 1.98, 1.63, 1.55, 1.17, 1.06 times, respectively. Cl and organic C were increased highly at section G (50-60 cm) about 1.90 times and 1.89 times, respectively. The pH value of the treated soil was slightly increased about 1.08 times and its highest values was found in section B (5-10 cm.).

The entire length of soil column was 60 cm. It was found that the accumulation of E.coli and both cations and anions i.e., NH_4-N, SO_4, Na, total-N, K, total-P, extractable-P in treated Khamphaeng Saen soil series occured in section A or 0-5 cm of the soil column. The highest value of pH was found in section B (5-10 cm). Contrary, Cl and organic carbon were accumulated at the end of soil column (50-60 cm) and Ca content and CEC value were quite high at 40-50 cm. The mobile NO_3-N was leached from Khamphaeng Saen soil between 10-60 cm of the length of column but the NO_3-N was accumulated highly in section A (0-5 cm).

4.4.3 Treated Muak Lek Soil

Figure 4.34-4.35 and **Table 4.6** show some chemicals properties and the content of E. coli in treated and untreated Muak Lek soil series. Most parameter were increased except extractable-P and Cl. Extractable-P contents in treated soil at section A-D (0-30 cm) were lower than untreated soil except at

Table 4.4 Changes in some characteristics of Khamphaeng Saen soil series in column which had been treated with domestic wastewater for 20 weeks.

characteristics of soil	Average Concentration before	Average Concentration after	A/B ratio times	Concentration in soil section after treatment (A-G) highest	Concentration in soil section after treatment (A-G) lowest
				length(cm)	
pH	6.13	6.65	1.08	B(5-10)	F(40-50)
TKN (%)	0.0728	0.1180	1.63	A(0-5)	D(20-30)
NH_4-N (%)	0.0004	0.0089	22.25	-	-
NO_3-N (%)	0.0047	0.0018	-	A(B-->G decrease)	
Total-P (ppm)	67.43	77.86	1.17	A(0-5)	B,G
Extract-P(ppm)	9.76	10.39	1.06	A(0-5)	D,E,G
Na (meq/100g)	0.27	0.53	1.98	A(0-5)	F(40-50)
K (meq/100g)	0.31	0.47	1.55	A(0-5)	B(5-10)
Ca (meq/100g)	11.5	14.96	1.31	E(30-40)	C(10-20)
Mg (meq/100g)	3.19	1.97	-	A(0-5)	D(20-30)
Cl (meq/100g)	0.09	0.08	2.52	C,D	A(0-5)
SO_4 (meq/100g)	0.03	0.08	2.52	G(50-60)	A(0-5)
Organic C (%)	0.73	1.02	1.38	G(50-60)	E(30-40)
CEC (meq/100g)	9.37	10.86	1.16	E(30-40)	C(10-20)
E. coli (col/g)	nil	2.13×10^3	-	A(0-5)	G(50-60)

Texture : Sand : Silt : Clay = 33.8 : 41.4 : 24.8

A/B ratio = after/before

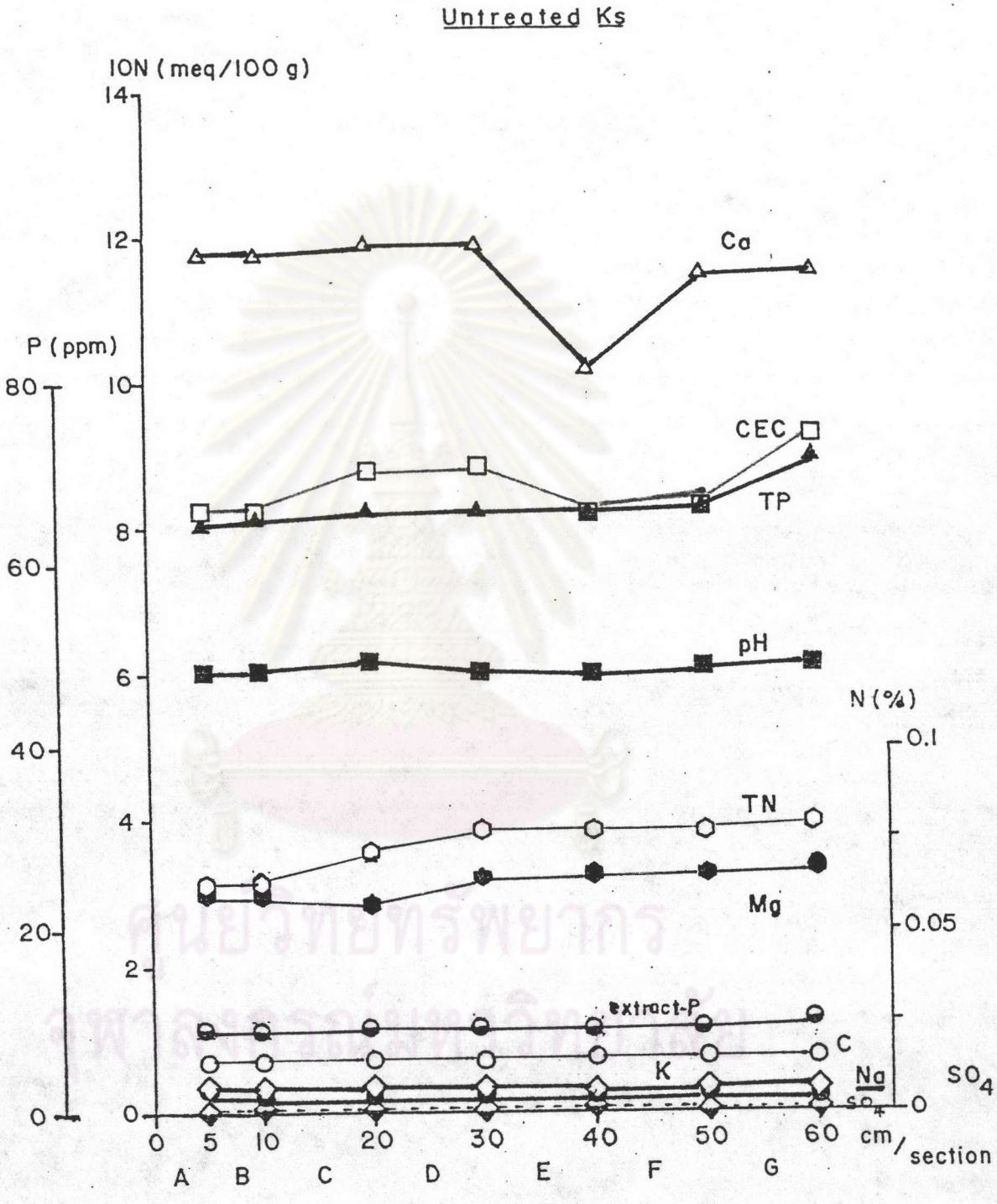

Figure 4.32 Characteristics untreated Khamphaeng Saen soil series

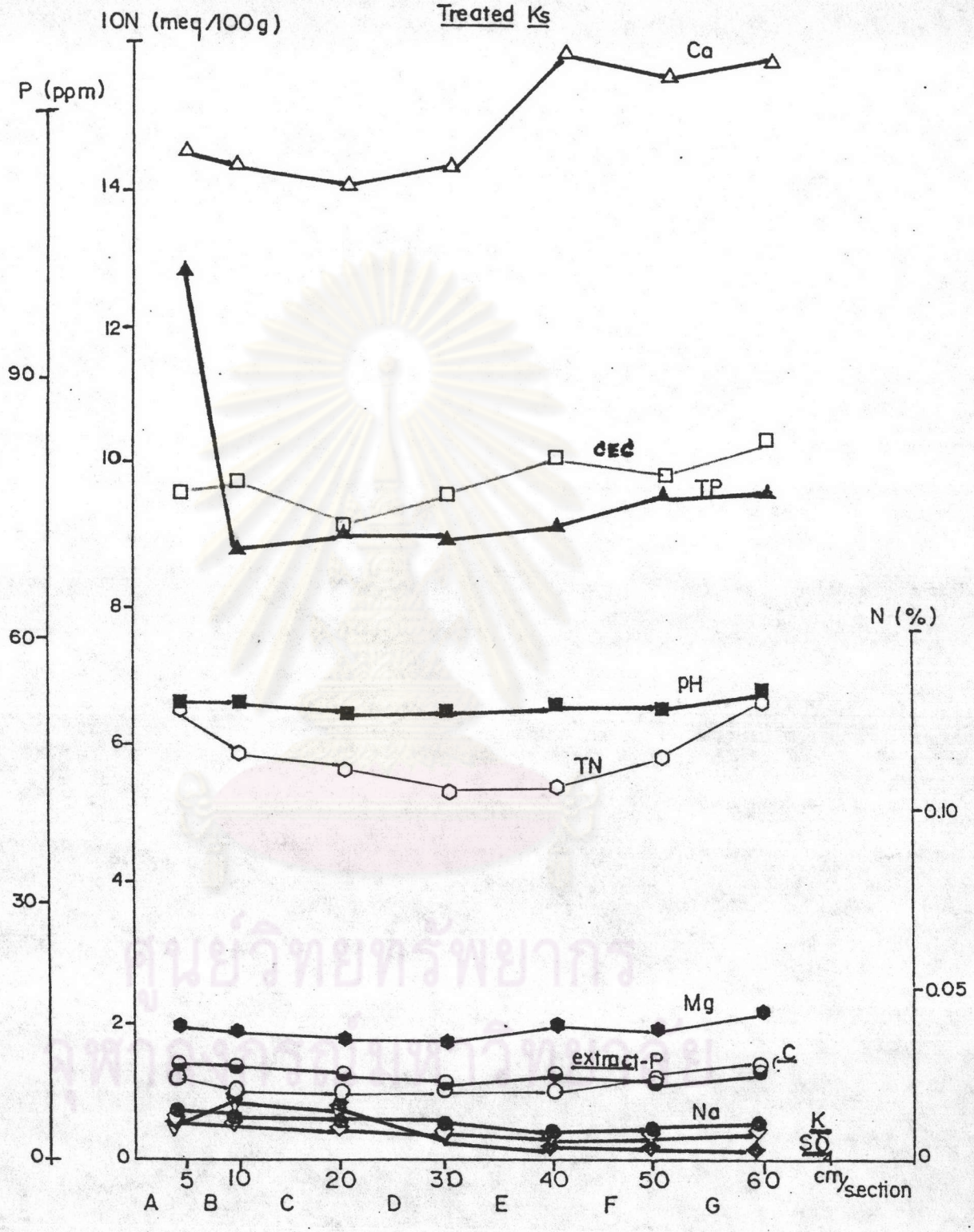

Figure 4.33 Characteristics treated Khamphaeng Saen soil series

sections E-G (40-60 cm). Cl content decreased at section A, while at sections B-G or 5-60 cm, its content increased. The highest contents of SO_4, organic carbon, Ca, Mg and CEC value were found in section A (0-5) and after/before ratio were 10.21, 1.45, 1.42, 4.32 and 1.18, respectively. E. coli, NH_4-N and NO_3-N in treated Muak Lek soil could be found, i.e., 6.06×10^2 col/g, 0.0243, 0.0013%, respectively, and they could not be detected in the untreated soil. The average value of pH was slightly increased from 7.5 to 7.73 and contents of K, TKN, total-P were sharply increased, i.e., 2.90, 2.33 and 2.16 times, respectively, **(Table 4.6)**. Contents of 6 parameters (E.coli, SO_4, Mg, organic C, Ca and CEC) were accumulated highly in section A (0-5 cm), but K content at 5-10 cm was quite high. Another of 3 parameters (Cl, total-P and extractable-P) were increased highly at 50-60 cm and Na at 20-30 cm and total-N at 30-50 cm.

4.4.4 Treated Ban Bung Soil

The texture of Ban Bung soil composed of sand about 79.6% **(Table 4.7)**. After passing of wastewater for 20 weeks, the average contents of most parameters increased except Ca **(Figure 4.36-4.37)**. Ca concentration at section A-E decreased whereas F-G (40-60 cm) increased. The highest increment of total P, Na, CEC, E. coli were found in section G, while the highest Cl and organic C contents were found in section F. Average extractable-P was increased and was found quite high at the length of 20-30 cm of soil column. Differently, the highest concentrations of Mg and TKN and the highest value of pH were found in section B, but the highest concentration of K was found in section B.

The accumulation of ions in Ban Bung soil column were different from the first 3 soil series. Most of them were found increasely at 40-60 cm of the length of soil column, i.e., Cl,

Table 4.5 Changes in some characteristics of Muak Lek soil series in column which had been treated with domestic wastewater for 20 weeks.

characteristics of soil	Average Concentration before	after	A/B ratio (times)	Concentration in soil section after treatment (A-G) highest	lowest
				length(cm)	
pH	7.50	7.73	1.03	B(5-10)	G(50-60)
TKN (%)	0.0413	0.0810	2.33	E,F	B(5-10)
NH_4-N (%)	0	0.0243	]	-	-
NO_3-N (%)	0	0.0013	-	-	-
Total-P (ppm)	20.71	42.83	2.16	G(50-60)	B(5-10)
Extract-P(ppm)	6.18	5.97	A-->D decrease E--->G increase		
Na (meq/100g)	0.38	0.61	1.67	D(20-30)	A(0-5)
K (meq/100g)	0.16	0.46	2.90	B(5-10)	G(50-60)
Ca (meq/100g)	17.46	24.61	1.42	A(0-5)	G(50-60)
Mg (meq/100g)	0.39	1.65	4.32	A(0-5)	G(50-60)
Cl (meq/100g)	0.05	0.20	4.00	G(50-60)	A(0-5)
SO_4 (meq/100g)	0.02	0.15	10.21	A(0-5)	E,F,G
Organic C (%)	0.368	0.53	1.45	A(0-5)	D(20-30)
CEC (meq/100g)	8.48	10.04	1.18	A(0-5)	E(30-40)
E. coli (col/g)	nil	6.06×10^2	-	A(0-5)	G(50-60)

Texture : Sand : Silt : Clay = 72.4 : 15.2 : 12.4

A/B ratio = after/before

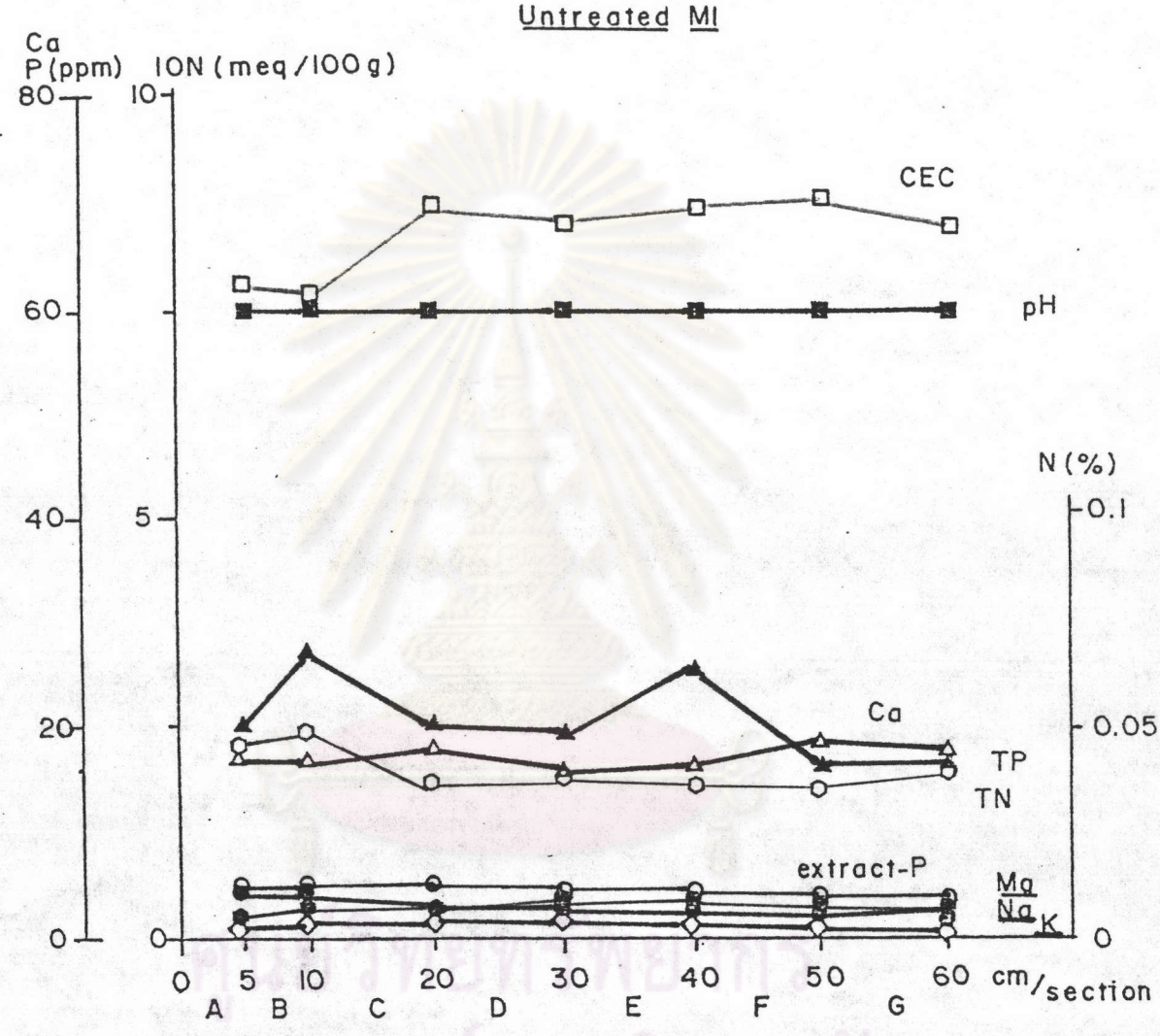

Figure 4.34 Characteristics untreated Muak Lek soil series

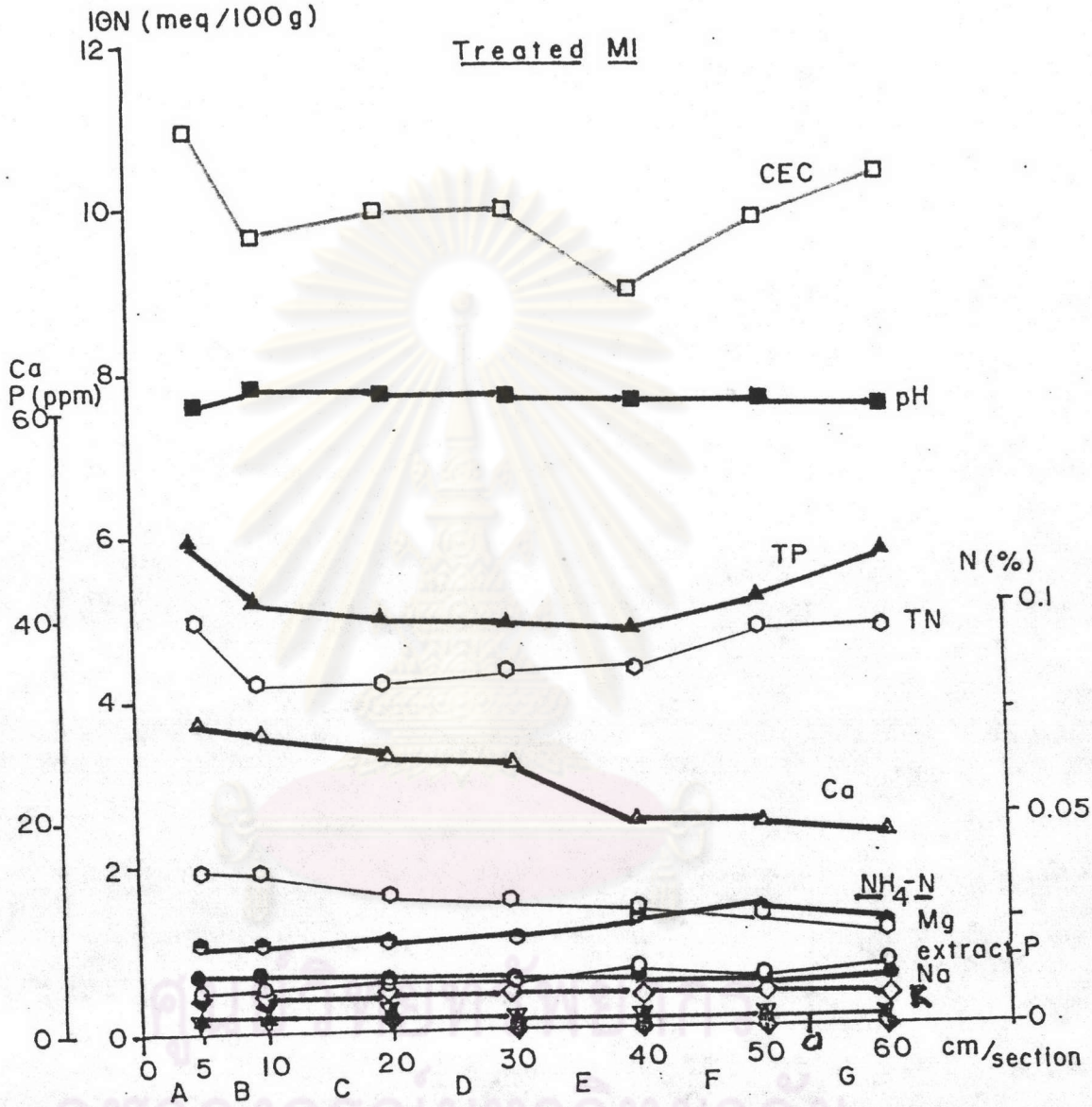

Figure 4.35 Characteristics treated Muak Lek soil series

Table 4.6 Changes in some characteristics of Ban Bung soil series in column which had been treated with domestic wastewater for 20 weeks.

characteristics of soil	Average Concentration before	after	A/B ratio (times)	Concentration in soil section after treatment (A-G) highest	lowest
				length(cm)	
pH	6.75	7.77	1.15	B(5-10)	G(50-60)
TKN (%)	0.0117	0.027	2.31	B(5-10)	F(40-50)
NH_4-N (%)	0	0.0063	-	A(0-5)	E,G
NO_3-N (%)	0	0.0005	-	A(0-5)	C,D
Total-P (ppm)	11.56	28.11	2.45	G(50-60)	A(0-5)
Extract-P(ppm)	5.46	10.16	1.87	D(20-30)	A(0-5)
Na (meq/100g)	0.18	0.35	1.84	G(50-60)	D(20-30)
K (meq/100g)	0.04	0.14	3.99	B(5-10)	E,F,G
Ca (meq/100g)	5.67	4.40	-	G(50-60)	D(20-30)
Mg (meq/100g)	0.07	0.6	8.94	B(5-10)	E(30-40)
Cl (meq/100g)	0.02	0.12	4.64	F(40-50)	C(10-20)
SO_4 (meq/100g)	0.03	0.15	4.27	C(10-20)	G(50-60)
Organic C (%)	0.133	0.19	1.44	F(40-50)	C(10-20)
CEC (meq/100g)	3.01	3.64	1.21	G(50-60)	D(20-30)
E. coli (col/g)	nil	7.64×10^2	-	A(0-5)	F(40-50)

Texture : Sand : Silt : Clay = 79.6 : 13.1 : 7.3

A/B ratio = after/before ratio

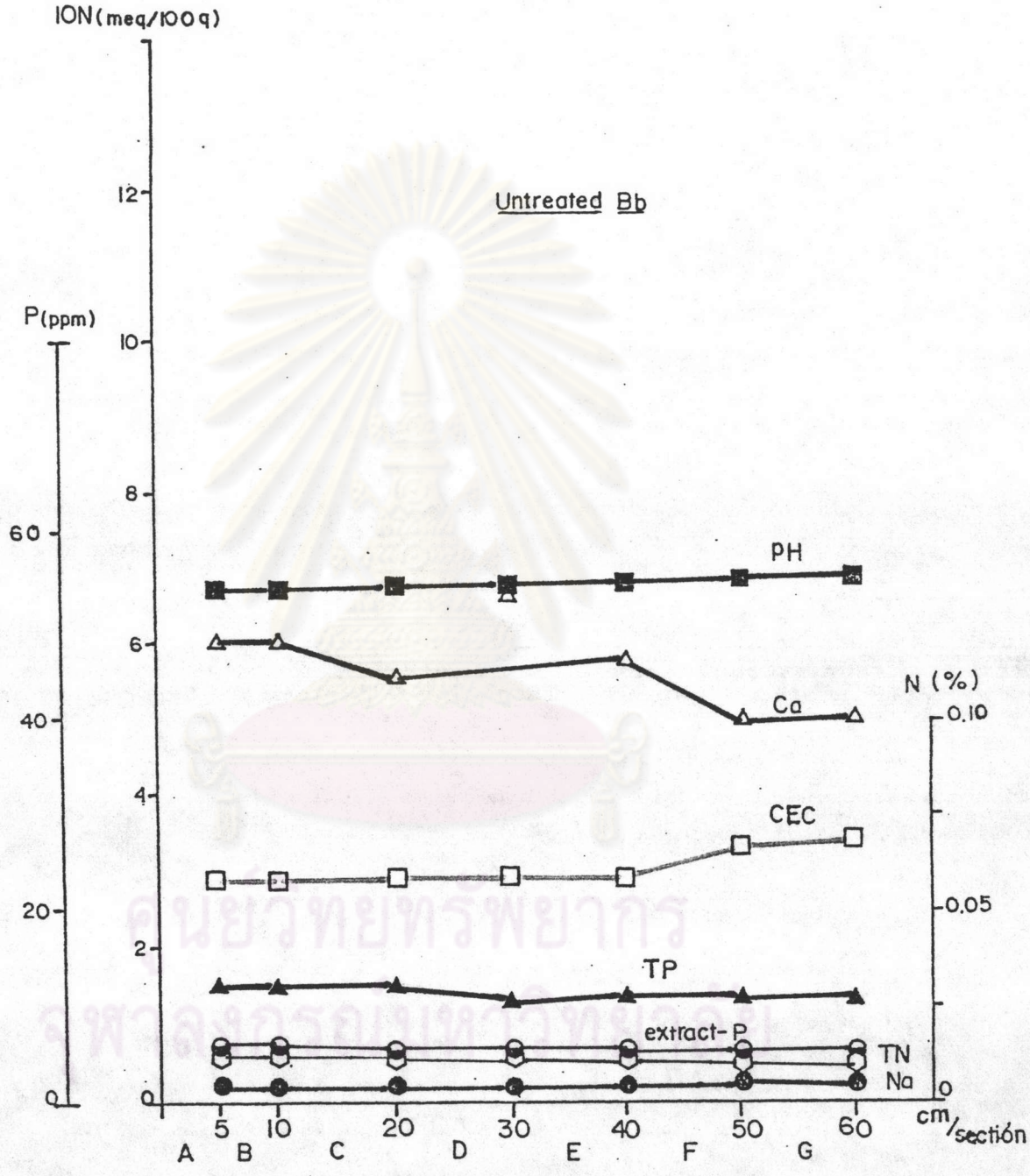

Figure 4.36 Characteristics untreated Ban Bung soil series

Treated Bb

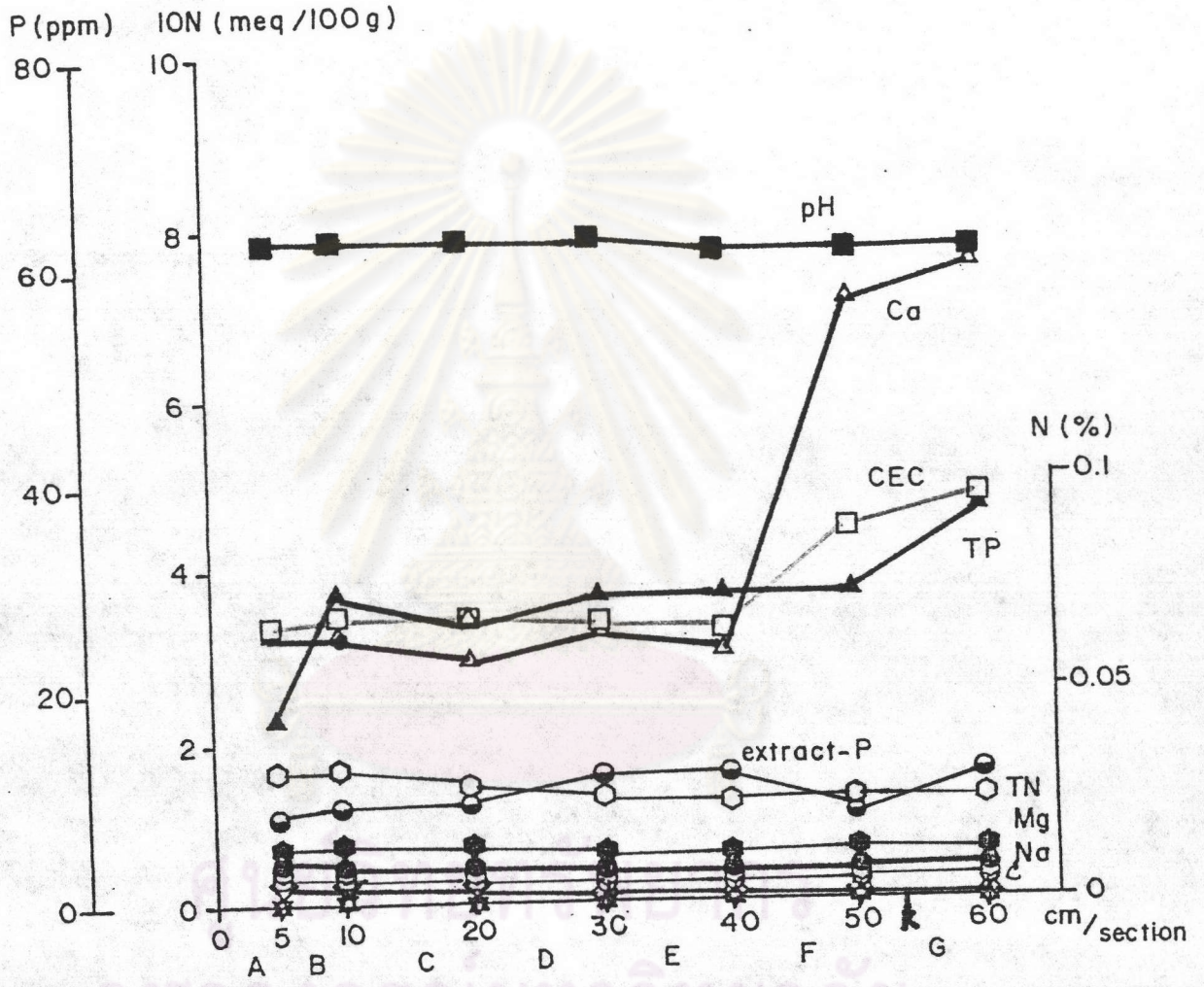

Figure 4.37 Characteristics treated Ban Bung soil series

total-P, organic C, CEC, Ca and Na. Extractable-P was increased highly at 30-40 cm, and followed by SO_4 at 10-20 cm and Mg, TKN, pH at 5-10 cm. NH_4-N and NO_3-N could be detected in the first section of soil column (0-5 cm) which could not be found in the untreated soil.

4.5 Relationship between Soil and Its Effluent

4.5.1 Pak Chong Soil Series and Its Effluent

After adding of 131.5 liters of wastewater into Pak Chong soil column, most ions in the influent, i.e., ortho-P, NH_4-N, SO_4, Cl, K and Na were immediately retained by the soil. For the first 5 weeks of wastewater passing through, it was found that K content in the Pak Chong effluent was slightly higher than its content in the influent. Certain amount of the original K content in the soil was gradually released or K leaching process occured. At the same time, Mg was also accumulated in the Pak Chong soil. Contents of Ca and Na in the Pak Chong effluent had been initially higher than those in the influent until week-11 **(Figure 4.26 and 4.30-4.31)**. It is indicated that Pak Chong soil which had been treated with domestic wastewater for a longer period of time (more than 20 weeks) may not adsorbed those ions from wastewater. NH_4-N of the effluent was gradually increased during the week-3 to the week-7, then declined and was lower than its content in the influent. Interstingly, NO_3-N could be detected at the same time. N-form in the treated soil, i.e., TKN NH_4-N, and NO_3-N were higher than those in the untreated soil. Most orthophosphate from the influent could be retained by Pak Chong soil. It was also found that increment of total-P was higher than the increment of extractable-P in the treated soil. It is indicated that, mechanisms of P-form removal from the wastewater may not be only sorption at soil surface but also

precipitation reaction. Soil pH, CEC and organic carbon content of the treated-Pak Chong soil was slightly increased and E. coli from the wastewater was also retained by Pak Chong soil.

4.5.2 Khamphaeng Saen Soil Series and Its Effluent

Compared with Pak Chong soil, it was found that 13.6 liters of wastewater or only 10% of the total amount of Pak Chong influent were added into Khamphaeng Saen soil column for 20-week period. The results showed that the quantities of K, Na and Mg in the effluent were higher than those in the influent. Contrary, total Ca content in the effluent was changed from higher to lower than its content in the influent at the week-6. However, the contents of Na, K and Ca (but not Mg) in the treated soil were higher than their contents in the untreated soil. It means that certain amounts of the original K and Ca in the Khamphaeng Saen soil may be released or leaching. In addition, very small amounts of orthophosphate, NH_4-N, SO_4 could be found for all the period of experiment. The results showed that the increment of total-P was higher than the increment of extractable-P in the treated soil especially,at 40-60 cm of Khamphaeng Saen soil column. The similar evidence was also found in case of N-form, i.e., soil TKN versus soil NH_4-N and NO_3-N. At the first 2 weeks of the experiment, Cl content in the Khamphaeng Saen effluent was marked higher, and after that, it was changed to be lower than its content in the influent. And it was also found that Cl content in the treated soil was slightly increased in all sections of the treated Khamphaeng Saen soil column. It was indicated that Cl accumulation or retention was occured in the Khamphaeng Saen soil. Soil pH, organic carbon and CEC of the treated soil were slightly increased. In case of Khamphaeng Saen soil treatment, E. coli could be detected in the treated Khamphaeng Saen soil.

4.5.3 Muak Lek Soil Series and Its Effluent

After passing of 110 liters of the wastewater through Muak Lek soil column, some ions, i.e., Mg, Cl and SO_4 from the wastewater or influent were retained by the Muak Lek soil. Contents of K and total Ca in the effluent were higher than their contents in the influent. Similarly, contents of Na, K and also Ca in the treated Muak Lek soil were higher than those in the untreated soil. In addition, total-P content was sharply increased in all sections of the treated Muak Lek soil column. In case of extractable-P, it was slightly decreased in all sections A-E (0-40 cm of soil column), but in sections F and G, their contents in the treated soil and also was higher than untreated soil. Ortho-P from added wastewater seemed to be adsorbed by Muak Lek soil at the first 5 weeks, then its content gradually increased until the end of experiment. Finally, it was found that ortho-P content in the effluent was nearly equal to its content in the influent. NH_4-N was immediately retained by the soil, it meaned that NH_4-N content in the effluent was sharply decreased and during week-1 to week-7, its content had been slightly increased but less than NH_4-N content in the influent. After 7 weeks, NH_4-N content in the effluent was gradually decreased again. At this period, NO_3-N could be detected and then was gradually increased. It was found that TKN in Muak Lek soil was increased in all sections. NH_4-N was mostly accumulated in the last 2 sections of soil column between 40-60 cm or sections F and G. In addition, viable count of *E. coli*, CEC value and organic carbon content in the treated Muak Lek soil were also increased.

4.5.4 Ban Bung Soil Series and Its Effluent

The highest volume of added wastewater of four-tested soil series for 20 weeks was found in Ban Bung soil column, i.e.,

167.6 liters. After treatment, the quantities of SO_4, Cl, Na and Mg in the effluent were lower than those in the influent for all period of the experiment. At the first week, K was adsorbed by Ban Bung soil and then it was initially decreased and then increased. It was found that K content in the treated soil was increased in all sections of Ban Bung soil column. Different from K pattern, total Ca in the effluent was higher than its content in the influent in the first 2 weeks, and after that Ca content was changed to be lower. Compared with untreated soil, the result showed that Ca content in the first end of the treated soil column (0-40 cm. or section A-E) was lower but its content in the second end (40-60 cm or section F and G) was higher, i.e., accumulation of Ca in Ban Bung soil. Total-P and extractable-P in the treated soil was found to be increased in all sections (A to G), especially, in the last section of Ban Bung soil column (50-60 cm). In 8 weeks of treatment, ortho-P in the influent or wastewater was clearly adsorbed by soil. After continuous adding of wastewater, ortho-P content in the effluent was slightly increased, anyway, its content had not been higher than ortho-P content in the influent. The pattern of NH_4-N in the Ban Bung effluent seemed to be similar to its pattern in Muak Lek effluent, i.e., its content was initially sharply decreased and then was gradually increased in small degree and NO_3-N could be detected. The result showed that after treatment, the pH value of both effluent and the treated soil were higher than the influent and the untreated soil. CEC value and organic carbon content in the treated Ban Bung soil was also increased, the evidence was similar to the first three-treated soil series.