CHAPTER 5

DISCUSSION

5.1 Characteristics of Domestic Wastewater or Influent

5.1.1 Weekly Variation

The results show that a week to week basis over a 20-week period there was little change in chemical composition of the domestic wastewater. Eventhough, wastewater from houshold was rather well-mixed, but quantitative change in certain parameter, i.e., Cl content, could be detected.

5.1.2 Comparison with Other Domestic Wastewater

Composition of domestic wastewater or influent from this report is compared with other recorded for Thailand, the United State of America, Canada and India (**Table 5.1**). There is good agreement in the composition of the influent in Thailand. COD loading and NH_4-N content in the influent in this report were rather higher than their loading in other groups. Variability in certain parameters among different groups may depend on seasoning variation and location size in the community (83). It is possible to say that the composition of the domestic wastewater among various location in the world seemed to be similar. However, the raw sewage from Canada (18) showed high concentrations of total phosphate and Cl. It is notes that NO_3-N could be detected in the influent from both U.S.A. and Canada (15, 18, 45, 86, 87).

Table 5.1 Comparision of Range and Mean value of Domestic wastewater analysed from U.S.A., Canada, India, and Thailand

	pH	COD	BOD	NH4-N	NO3-N	Total-P	Ortho-P	K	Cl	SO4	E.coli	Remark
Thailand												
1	7.23-8.0 7.8	398-765 602	301~	40-58 48.55	trace	8.3-11.95 9.82	6.1-9.2 7.68	8.7-16.6 11.35	81-120 96.06	29-46 38.04	10E4-10E6 1.65E6	This study
2	7.1-7.5 7.4	306-504 393	196.5~	30-40 40	trace	7.9-8.2 8.9	6.2-7.5 6.8	-	-	-	8E5-4.8E6 8.3E6	Ref (1)
3	-	222.6	114.3	21.79	-	-	-	-	-	-	-	Ref (84)
4	7.1-7.7 7.4	198-850 356.4	95-345 192.5	15-35 23.7	-	-	-	-	-	-	-	Ref (85)
5	7.1-7.3 7.2	65-342 148	50-96 79.2	11-32 21.2	-	-	-	-	-	-	-	Ref (85)
U.S. army, cold region. U.S.A.	6.9-8.0 7.4	~202.6	47-161 101.3	1-62 22.1	0-9.0 0.6	1-15 7.0	-	0.4-13.8 8.3	14-122 36.1	-	2E3-9.2E5 2.4E5	Ref (86)
Raw sewage; Canada	6.6-9.1 7.63	350-2880 1166	397-582 484	6-227 71.3	0-0.12 0.12	2.5-45 18.9	-	-	21-296 162.7	-	600-6E6 1.05E6	Ref (18)
India, Sump well	7.8-8.1 7.9	67-230 120	96	13-22 17.6	-	6.3-11 8.9	-	-	-	-	-	Ref (87)
Loveland, Ohio, U.S.A.	7.0-8.1	33-393 190	14-172 87	5-78 24	0-0.95 0.08	13-74 38	-	-	-	43-154 92	-	Ref (15)
Wisconsin, U.S.A.	-	113-394 257	-	30-45 34	< 1	15.6-25.4 20.6	-	-	-	-	-	Ref (45)

5.2 Characteristics of Effluent

5.2.1 Weekly Variation

The results show that weekly basis over a 20-week passing of domestic wastewater through columns of different soils, i.e.,Ban Bung loamy sand, Pak Chong clay, Muak Lek sandy loam and Khampaeng Saen loam, their were changes in some physical, chemical and biological characteristics of the effluent in different degree. Especially, in the first six weeks of the experiment, COD loading, viable E. coli and content of Na, Cl and NH_4-N in all four effluent, Ca content in Pak Chong, Muak Lek and Khamphaeng Saen effluent, SO_4 content in Ban Bung and Pak Chong effluent and K content in Muak Lek effluent were changed markedly. And also NO_3-N could be detected in Ban Bung , Pak Chong and Muak Lek effluent in this period (week-5). Changes in the remaining parameters seemed to be in the narrow range. It is possible that changes in effluent characteristics may depend on soil texture, soil microorganisms, original concentrations in soil and influent ions or chemicals (52).

5.2.2 Physical and Biological Changes

Effluent from Khamphaeng Saen and Ban Bung soil columns were colorless which Pak Chong and Muak Lek effluent showed to be slightly yellowish. Effluent color may depend on origin color of the domestic wastewater used, soil color, microbiological activities and flow rate of the wastewater (7). Anyway, E. coli could not be detected in any of the four effluent. It may be that some E.coli could be died before seep through soil. But it could be found E.coli in effluent from 4 soil series in the first period of experiment. Thus It may conclude that soil is one of the effective media for filtering of microorganisms which contaminates in domestic wastewater (71).

5.2.3 Plant Nutrients in the Effluent

As we know, essential plant nutrients are N, P and K and their ions can be detected in the domestic wastewater or influent. The results show that some soluble forms of all above three nutrients were found in the effluent except in the Pak Chong and Khamphaeng Saen effluent which soluble-P form could not be detected. It is noticed that there was no NO_3-N form in the influent but certain amount of NO_3-N could be found in only three effluent from Ban Bung, Pak chong and Muak Lek soil columns. The results indicate that there should be nitrification process occurred in those soils (31). In addition, soluble K was detected increasingly in all effluent, and it is said that leaching process of fixed form K occurred in those soil columns (28). The total amount of soluble form of N, P, and K in the influent would be high enough for using them especially effluent from Ban Bung, Pak Chong and Muak Lek soil columns for plant nutrients (82). Other ions, i.e., Na, Cl, Ca and Mg that leached from the treated soil were also found in the effluent. However, the leachates may be polluted to natural water resources including ground water (88). By suitable management, prevention processes should be performed, e.g., plant cropping in certain areas and liquid growth medium (6).

5.2.4 Comparison of Other Effluent

Removals of cations and anions by soil column both in vertical and horizontal directions seemed to be similar (1, 2). Except in PO_4-P, this form could be found again after treatment for a long time. Several mechanisms could be established, i.e., regeneration sorption capacity (49, 89), and anaerobic or reduced condition (37).

5.3 Soil characteristics before Domestic Wastewater Treatment

Quantities of some characteristics of the four-untreated soils, i.e., Ban Bung, Pak Chong, Muak Lek and Khamphaeng Saen with those from Soil Survey Laboratory (77, 78, 79, 80). It is good agreement in certain tested parameters except Ca content and soil pH. It was found that the ranges of certain parameters in Khamphaeng Sean soil series from soil survey lab were varied widely, i.e., 5-19 meq/100g for CEC and 1.3-38 meq/100g for Ca and 3.4-67 ppm for extractable-P. Thus, CEC value, extractable-P and Ca content were lower than the average values from this study, but it had been accepted. The variation in soil chemical properties may depend on parent materials, location and variety of plant growing (21).

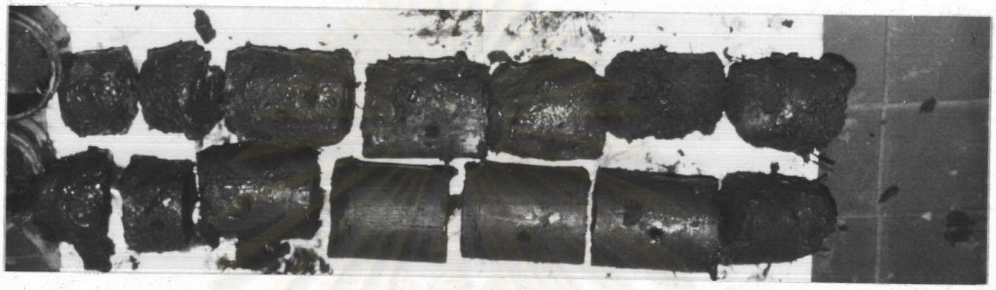
5.4 Soil characteristics After Domestic Wastewater Treatment

5.4.1 Physical Changes.

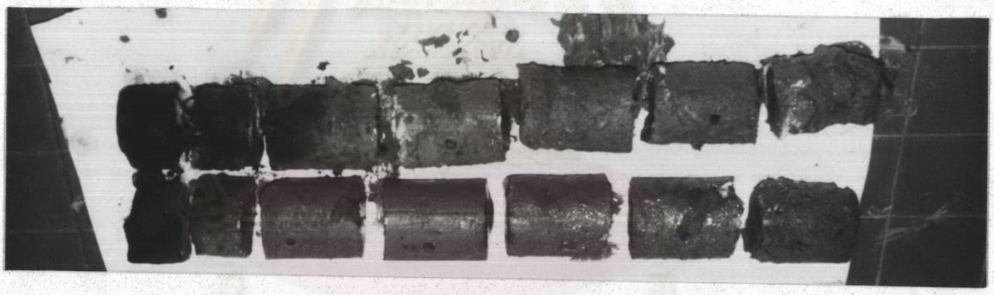
5.4.1.1 Soil Color

Color of the treated soils was changed to be black or dark-brown in certain part of soil columns, especially, in the first part or 0-30 cm. from wastewater column. The length of black color in the soil column may depend on flow rate of wastewater (**Figure 5.1**). Occurrance of black or dark-brown color in the treated soil indicates that trapping capacity of soil for suspended solid or biomass from domestic wastewater may concern (7).

Pak Chong soil serie



Khamphaeng Saen soil serie



Muak Lek soil serie

Ban Bung soil serie

Figure 5.1 Photograph of soil color after passing with wastewater

5.4.1.2 Soil Clogging

Percolation rate in soils in horizontal (140-day treatment) and vertical directions (45-day treatment)(1) could be compared. In the first system, wastewater can flow through whereas in the latter one wastewater moves by gravity which the total amount of the latter one would be gradually declined and finally stopped. Mc Gauhey and Bouma (7,19) proposed that depending on the flow direction in the soil column, sedimentation would occur in the bottom and also move through the sidewalls. In the contrary, vertical direction may be both gravity and infiltration act to deposit solids on the horizontal face of soil column, and gravity tends to strip the vertical face of settleble matter. Rates of permeabilily in different soils differ and may due to particle size and type of clay. Compared with Khamphaeng Saen loamy soil, the quantity of clay particle in Pak Chong soil was the highest but its permeability rate was the second. This evidence may depend on type of clay minerals in the soil. In Pak Chong soil series, its clay mineral composed of kaolinite which is 1:1 type where as in Khamphaeng Saen soil series have montmorillonite which is 2:1 type (79, 90).

5.4.2 Chemical Changes

5.4.2.1 pH

Soil pH of four-treated soil increased particularly in Ban Bung soil series and this phenomenon dues to the fact that soil with good permeability could remove bases from the influent. However, the small increment of pH in Pak Chong and Khamphaeng Saen soils were probably due to clay materials act as buffers (91). He showed that in sandstone clay mixtures, pH changed from 7.8 to 6.9 for 12 % clay and 5.4 for 0 % clay after treatment with septic tank effluent for 23 weeks. Similarly, soil pH small increment in sludge amended soil (24).

5.4.2.2 N-transformations

Treated Ban Bung, Muak Lek and Pak Chong soils may be trapped NH_4-N from wastewater. In the first period of adding wastewater, NH_4-N may be bound to negatively charges of clay and organic colloids in the soil particles, then soil probably be saturated with NH_4-N. This result from 4.2.3.1 supported this mechanism. In addition, Magdoff(45) found that NH_4-N decreased sharply after treated of the soil columns for 10 weeks. However, NH_4-N in this soil could be exchange readily with other cations (Ca,Mg) and acessible to nitrifying bacteria (33) after passing of wastewater continuously. But Khamphaeng Saen soil series removed N-form from wastewater by fixing NH_4-N in the crystal lattice. Therefore, the N content in treated Khamphaeng Saen soil was largely found in total-N in forms. However, some of N in the influent could be immobilized in microbial tissue (86).

5.4.2.3 P-transformations

Treated soil could be retained P from wastewater by sorption and precipitation. The relationship between adsorption and precipitation can be shown by the equilibrium reaction (21):

P adsorped -------> P in solution ---------> P precipitated

Mechanism of P sorption by soil depends on texture and amount of hydrous oxide of Al/Fe (28). The latter reaction occurs after accumulating P for a long period of time and in suitable soil pH (46). As result from 4.2.4.1, Muak Lek and Ban Bung soils may remove P from the influent by sorption reaction until reached equilibrium or saturated. Therefore, it could be found P in the effluent after passing wastewater for 12 weeks. In addition, PO_4-P could be found in the effluent again. It is possible that PO_4-P which firstly had be taken up by soil microorganisms and after they died,available-P was again rendered and leached from the soil column. In the effluent from the four treated soils, the results show that the dip in PO_4-P concentration would coincide with a peak of Ca concentration (**Figure 4.6 and Figure 4.2**). It is indicated that P removal may be caused by precipitation of Ca-P compounds for a long period of domestic wastwater treatment. the quantity of total-P in the soil was higher than the extractable-P quantity in the four treated soil series strongly supported the evidence.

5.4.2.4 <u>The Movement of Cations</u> (Ca, Mg, K, Na)

Soluble K, Na and Mg ions were retained in Pak Chong, Muak Lek and Ban Bung soil series after passing wastewater immediately. After that high Na content in the influent displaced K, Mg ions from the soil exchange site (53). However soil K, Na, and Mg increased in treated three soil series. It may be due to adsorption reaction and fixed form of K probably released as follow by the equilibrium reaction (57):

nonexchangeable K ------> exchangeable K -------> in soil solution

In addition, total Ca content in effluent from 4 soil series was higher than influent in the first 4 weeks. Soil Ca increased except Ban Bung soil series. It is possible that some Ca ions precipitate with PO_4-P (46). After taht the ion could be adsorped at the soil exchange site. In contrast, Mg, K and Ca ions were released from Khamphaeng Saen soil and could be retained Na at the first period of experiment. It is possible that their content in the tested Khamphaeng Saen soil were higher. Therefore, their ions may be leaching when passing wastewater continuously.

The pattern of Na in Muak Lek and Ban Bung effluent at the first period of experiment nearly constant and almost equal

Na concentration in influent. It indicated that Na content in those soil may be reach equilibrium. This result is same as De Jong (55) indicated that the steady state of Na due to percolation and the CEC of soil were low. When comparation between the movement of 4 cations in Pak Chong, Muak Lek and Ban Bung soil series was clearly affected by exchange reaction; Na and Ca approached equilibrium values after 5 weeks has leached through the soils but Mg concentration in the effluent were still considerably lower than influent at the end of experiment. This result agree with the result of De Jong (56) that Na in the leachate was retarded before 3 pore volumes while Ca was desorbed and Mg was desorbed or adsorbed to a lesser extent than later in the experiment. However, the result from 4.3.1-4.3.4 indicated that the exchangeable Ca of the soil is too high relative to the exchangeable Mg. Readjustment of exchangeable Ca vs. exchangeable Mg can take place by adsorption of Mg. while Ca desorbed, or by adsorption of Mg as the sum of the exchangeable (Na+K+Ca+Mg) increase during 20 weeks. Almost K are highly adsorb in the first period as shown that K concentration decrease to 0 mg/l. Then its content reversed to fix-form of K released simulataneous. Thus, the amount of adsorption or desorption to an extent depend upon texture and percolate rate of soil. Except in Khamphaeng Saen soil serie, the pattern of K, Ca and Mg are highly desorbed from soil due to its contaminated fertilizer. Therefore, the result would not to indicated that salt movement.

5.4.2.5 The Movement of Anions (Cl, SO_4)

The soluble SO_4 could be detected higher at first section which receiving influent earily. In case of Muak Lek series highly retained SO_4 as equal as Pak Chong soil series. It may be the occurence of precipitation, $CaSO_4$. Since Muak Lek soil series before treatment have plenty of Ca concentration. This

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Cl movement showed the different trend. It is higher at section F and G. It may be explained that Cl ions are freely move with water through soil column a long period of experiment, and the efficiency of soil to retained Cl depend on soil texture and percolation rate (68).

5.4.2.6 Organic Carbon

The organic carbon content were increased in the four treated soil. It is possible that soil accumulate of suspended materials by physical filtration as seem in decreasing the amount of COD in the effluent **(4.2.8)**.Thus , soil column neither retained the chemically oxidizable materials nor allowed then to be oxidized during domestic wastewater passing through the column. Because quantity of organic carbon increased in each soil series, it indicateed that organic matter would be increased in each soil (17) and probably be found humus after continueous passing. However, changes in soil organic carbon was slight and not consistant. This could be due to the relatively short period of passing of wastewater (86).

5.4.2.7 CEC value

The increasing in CEC may be attributed to increasing in pH after domestic wastewater treatment (38). The results **(4.2.9)** showed that increasing in CEC in Pak Chong soil was rather high compared with in Ban Bung soil, its CEC and pH was increased slightly. It is possible that highly increase in CEC of tropical soils may also resulted from P sorption (92). In addition slightly changes in soil CEC may be attributed to higher mineralization rate of organic matter.

5.4.3 Biological Changes

Not only pathogenic bacterial cell in the soil also but soil microbe are enhanced as a result of passing of wastewater , i.e.,nitrifying bacteria (32). The quantities of microorganisms in soil depend on soil texture and environmental conditions i.e., nutrients, moisture, pH and temperature (19). However, *E. coli* content at the end of soil column (30-60 cm) found lower than the first one (0-5 cm). It is possible to say whether the die-off of the *E. coli* resulted from unsuitable condition or decreased mostly at first section (72).

5.5 Plant Nutrients in Treated Soils

Constituents of treated-soil may be changed after passing of wastewater. Certain properties are suitable for plant nutrients (82) as shown in **Table 5.2.** The high leaching of sulfate and fixed form of soil K may be noted. However, available-P and organic carbon in the treated soil slightly increase. The evidence may be due to the certain period of the experiment and intermittently passing of wastewater (25, 47).

Table 5.2 Estimated treated characteristics soil for plant nutrient

constituents	Pc	Ks	Ml	Bb	plant level			
					Pc	Ks	Ml	Bb
K meq/100g	0.5	0.47	0.46	0.14	high	very high	high	low
N %	0.21	0.11	0.08	0.03	med	low	low	low
available P ppm	23.4	10.4	5.9	10.2	med	low	very	low
organic C %	2.4	1.02	0.53	0.19	med	low	very low	very low
Ca meq/100g	16.7	14.9	24.6	4.4	med	med	high	low
Mg meq/100g	2.31	1.9	1.65	0.6	med	low	low	very low
Cl meq/100g	0.27	0.17	0.2	0.12	adequate	low	adequate	low
SO_4 meq/100g	0.2	0.08	0.15	0.15	very high	very high	very high	very high
Na meq/100g	0.84	0.53	0.61	0.35	high	med	med	med