CHARPTER 3

RESULTS AND DISCUSSION

3.1 Preparation of a calibration graph

A calibration graph is constructed on logarithmic concentration of fluoride when a pH/mV meter was used for measuring the potentials as presented in Fig. 3.1 and Table 3.1 presents a data set of the experiments.

Table 3.1 Logarithm of the concentrations and the voltage of standard fluoride solutions

Concentration of standard fluoride solution, mg/l	Log of concentration	Voltage, mV
0.5	-0.30	212
1.0	0.00	197
2.0	0.30	179
4.0	0.60	161
6.0	0.77	151
8.0	0.90	143
10.0	1.00	138
50.0	1.69	96
100.0	2.00	78

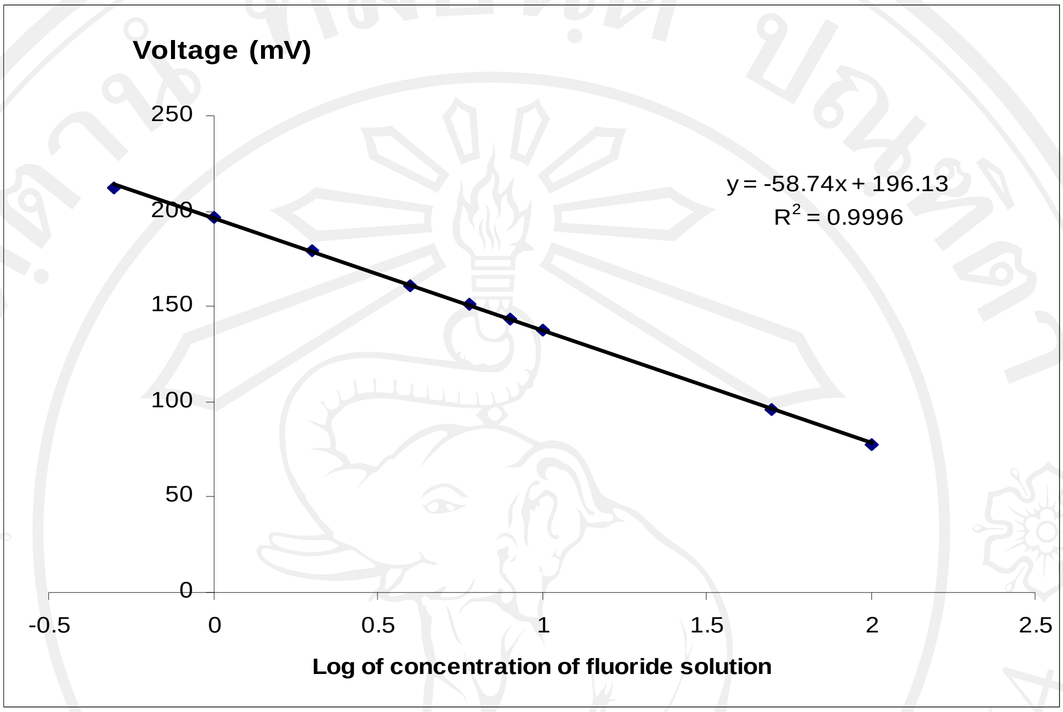

Fig. 3.1 Calibration graph of standard fluoride solutions

From the standard fluoride calibration curve, its slope can be used to confirm whether the electrode is in a good operating condition or not by considering the slope of the calibration curve that having a change within 57±2 mV [21]. The value of the slope of this electrode is 58.74 mV. Therefore this electrode is regarded as being in a good operating condition which is reflected by the linearity of standard fluoride curve through the R^2 value of which equals to 0.9996. Therefore, this value confirms good precision and accuracy and good response of fluoride ion selective electrode being in use.

3.2 Selection of the extractants

The extraction of fluoride by four different extractants i.e. deionized distilled water, ammonium acetate (CH_3COONH_4), calcium chloride ($CaCl_2$) and hydrochloric acid (HCl) resulted in the percent recovery as follows, 59.86 % of deionized distilled water, 53.37% of ammonium acetate, 41.02% of calcium chloride and 1.22% of hydrochloric acid (Fig. 3.2). The recovery increases in the order of hydrochloric acid < calcium chloride < ammonium acetate < deionized distilled water, respectively. It is evidently shown that the strength of eluting power has no meaning in removing the loosely bound fluoride, just simply pure water is enough in this case. Deionized distilled water is proven to be the most efficient extractant due to the purity of the solvent itself. Deionized distilled water does not contain any solute in its body at all that makes room for fluoride which is loosely bound in the soil to dissolve extensively. Therefore, deionized distilled water was selected as an extractant.

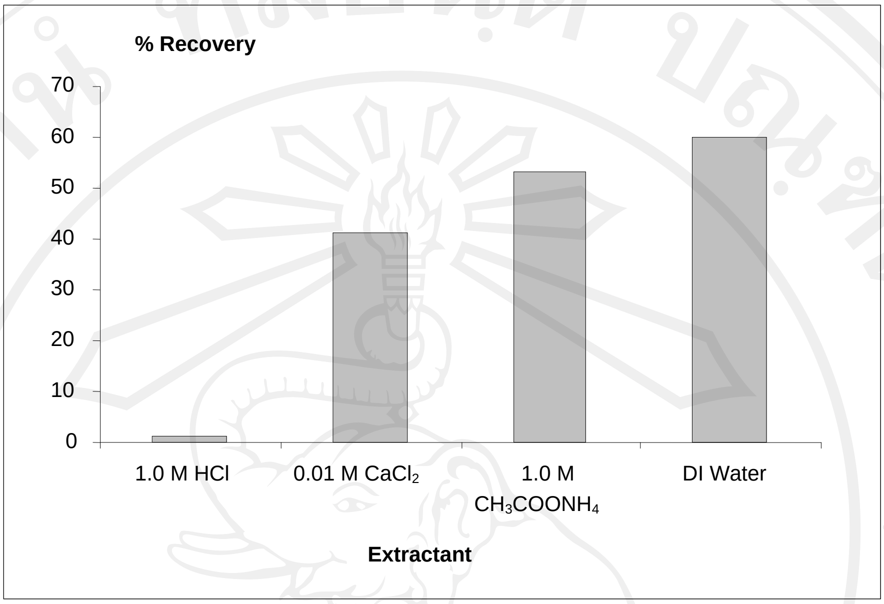

Fig. 3.2 Percent recovery of fluoride using 4 different extractants ; deionized distilled water, ammonium acetate (CH_3COONH_4), calcium chloride ($CaCl_2$) and hydrochloric acid (HCl).The extraction done by using 15 ml of the extractant volume for 60 minutes at room temperature.

3.3 Optimization of extraction conditions

As the univariate method was applied to this study, the effect of temperature was the next-in-line parameter to be studied by performing the extraction at 50, 60, 70, 80 and 90°C, respectively, while the condition of the remaining parameters were fixed as previously done. Fig. 3.3 reveals the effectiveness of removing the fluoride with the following percent recovery; 67.60% (50°C), 74.73% (60°C), 82.82% (70°C), 102.08% (80°C) and 96.91% (90°C). Thus, 80°C was selected as the optimum extraction temperature.

The effect of extraction volume was studied by using 10, 15, 20, 25 and 30 ml of deionized distilled water. The percent recoveries in fluoride extraction were of

71.02%, 100.05%, 101.57%, 101.08% and 100.49% with the extractant volume of 10, 15, 20, 25 and 30 ml, respectively. The result shown in Fig. 3.4 indicates that 15 ml of deionized distilled water is the optimal value for extracting fluoride.

The optimum extraction time determined by shaking the mixtures at 30, 60, 90 and 120 minutes, resulted in the percent recovery as 77.85%, 92.69%, 103.91% and 84.92% respectively (Fig. 3.5). The highest recovery is found in the extraction for 90 min, thus cause it to be chosen as the optimal extraction time.

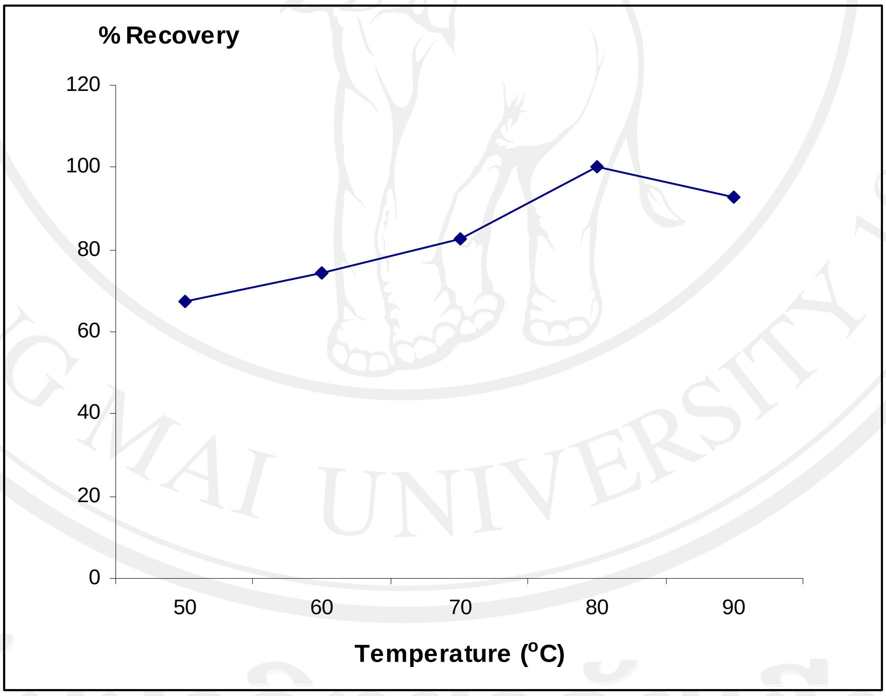

Fig. 3.3 Percent recovery of fluoride from the extraction at the temperatures of 50, 60, 70, 80 and 90 °C. The extraction done by using 15 ml of the extractant volume for 60 minutes.

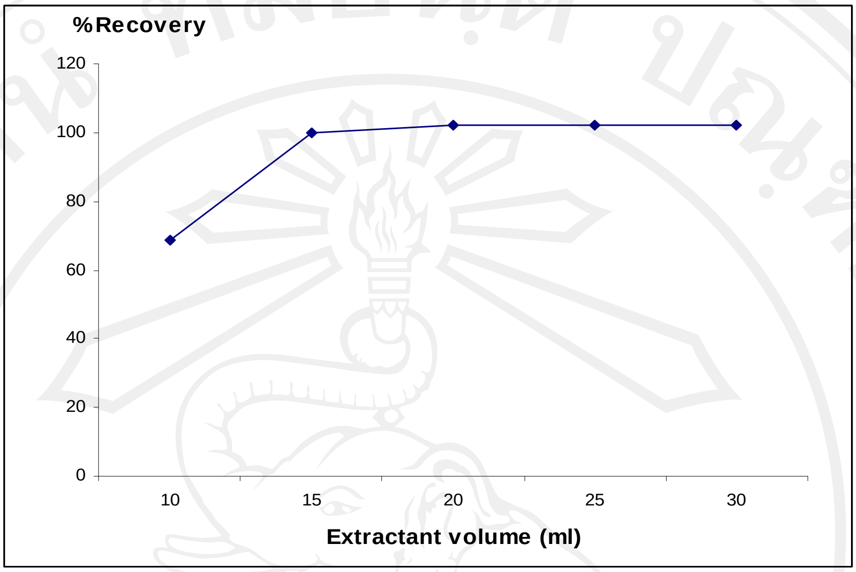

Fig. 3.4 Percent recovery of fluoride from the extraction using the extractant volumes of 10,15, 20, 25 and 30 ml. The extraction done for 60 minutes at 80 °C.

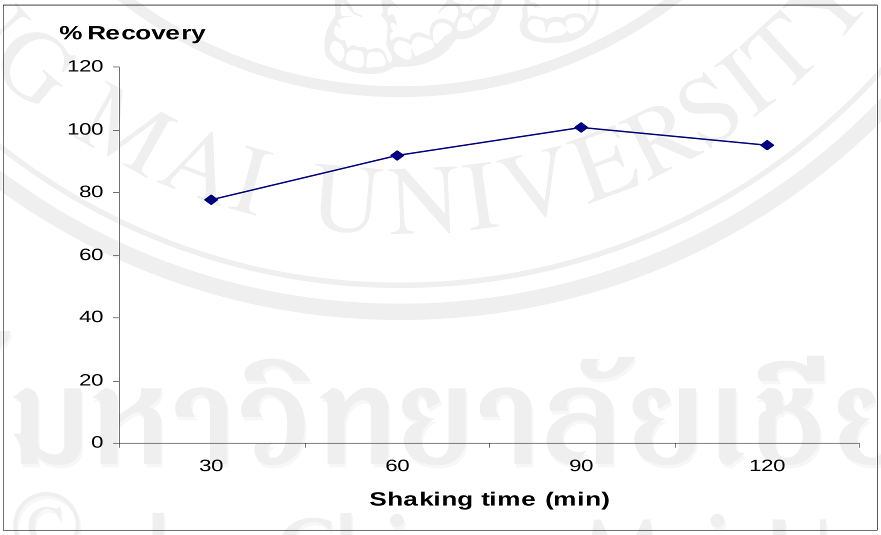

Fig. 3.5 Percent recovery of fluoride from the extraction by shaking for 30, 60, 90 and 120 min. The extraction done by using 15 ml of DI water at 80 °C.

3.4 Fluoride Distribution in Soil

The fluoride distribution in soils at the installation points of the reverse osmosis-drinking water vending machines was studied through the samples collected from five different villages in Amphoe Mueang and Amphoe Ban Thi. These villages have high fluoride in water sources, thus, the reverse osmosis-drinking water vending machines are installed to get rid of fluoride in water. The discarded water from the reverse osmosis process is disposed to the ground causing the fluoride to distribute and accumulate in the soil. The fluoride distribution in the soils will vary differently depending on the topography of the locations of the installed machines and the soil characteristics that can be described for each area as follows:

3.4.1 Soil collected from Ban Luk

Soil samples collected from Ban Luk contain fluoride ranging from 44.6 to 133.1 mg/kg that can be grouped by soil depth. The fluoride content at the depth A (0-20 cm) ranged from 44.6 to 133.1 mg/kg, while the content at the depth B (20-40 cm) ranged form 29.9 to 108.5 mg/kg and at the last depth C (40-60 cm) contain fluoride from 14.8 to 48.4 mg/kg. As being presented in Table 3.2, it can be seen that the accumulation of fluoride at different depths is in the order of A >B >C. Considering the soil characteristics from the global positioning system (GPS), it was found that the soil in this area belongs to Chiang Rai soil series. This type of soil is a mixture of silt and clay, therefore its properties are poor water draining, slow water permeation and slow flow of surface water [23]. This causes the accumulation of fluoride to occur more on the upper layer than the lower one. From Fig. 3.6, it can be observed that at the discharged point #2, the fluoride content was found to be more than other positions due to the topographic nature of being a flat land, like position # 1 and 3, while the positions # 4, 5, 6 and 7 are slopy and inclined to the water resource.

Table 3.2 The fluoride content in soil sample for each layer of Ban Luk

Location Villages/Districts	Positions	Layers	Fluoride content in soil 1 g (mg)	Fluoride content (mg/kg)
Ban Luk Tambon San Pa Sak Amphoe Mueang	1	A	72.5×10^{-3}	72.5
		B	54.6×10^{-3}	54.6
		C	48.4×10^{-3}	48.4
	2	A	133.1×10^{-3}	133.1
		B	108.5×10^{-3}	108.5
		C	44.6×10^{-3}	44.6
	3	A	75.5×10^{-3}	75.5
		B	52.2×10^{-3}	52.2
		C	42.9×10^{-3}	42.9
	4	A	44.6×10^{-3}	44.6
		B	32.3×10^{-3}	32.3
		C	31.0×10^{-3}	31.0
	5	A	63.4×10^{-3}	63.4
		B	52.5×10^{-3}	52.5
		C	35.9×10^{-3}	35.9
	6	A	78.6×10^{-3}	78.6
		B	58.4×10^{-3}	58.4
		C	39.6×10^{-3}	39.6
	7	A	51.1×10^{-3}	51.1
		B	29.9×10^{-3}	29.9
		C	14.8×10^{-3}	14.8

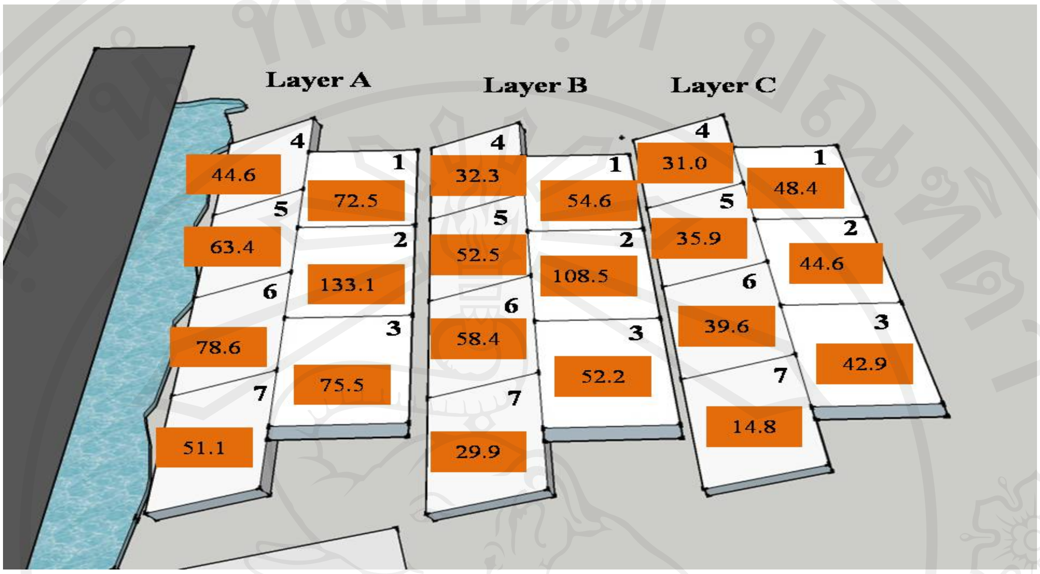

Fig. 3.6 Distribution of fluoride (mg/kg) at each soil depth according to soil sampling positions (orange band) of Ban Luk

3.4.2 Soil collected from Ban Mae San Pa Daed

Due to the type of the soils at Ban Mae San Pa Daed is the same as those at Ban Luk which is the Chiang Rai series, the fluoride distribution pattern is therefore about the same. That is the accumulation of fluoride in each soil depth is in the order of A >B >C of which the contents at each depth are 4.5 to 15.5 mg/kg, 3.6 to 11.0 mg/kg and 1.9 to 8.6 mg/kg respectively (Table 3.2). However, the amounts of fluoride accumulated in the soil at this location is less than those at Ban Luk which means that the characteristics of the soils at Ban Luk must be more loamy. Comparing the fluoride distribution at different discharge points, it was found that, at positions 3, 2 and 1, distribution of fluoride appeared to be more than the positions 4,5 and 6 because the flow direction of the discharged water occurred from the positions 3, 2 and 1 to the opposite positions of 4,5 and 6 (Fig. 3.7)

Table 3.3 The fluoride content in soil sample for each layer of Ban Mae San Pa Daed

Location Villages/Districts	Positions	Layers	Fluoride content in soil 1 g (mg)	Fluoride content (mg/kg)
Ban Mae San Pa Daed Tambon Wiang Yong Amphoe Mueang	1	A	10.9×10^{-3}	10.9
		B	8.6×10^{-3}	8.6
		C	8.3×10^{-3}	8.3
	2	A	12.9×10^{-3}	12.9
		B	9.4×10^{-3}	9.4
		C	6.6×10^{-3}	6.6
	3	A	15.5×10^{-3}	15.5
		B	11.0×10^{-3}	11.0
		C	7.9×10^{-3}	7.9
	4	A	9.7×10^{-3}	9.7
		B	6.0×10^{-3}	6.0
		C	4.7×10^{-3}	4.7
	5	A	5.6×10^{-3}	5.6
		B	4.2×10^{-3}	4.2
		C	2.4×10^{-3}	2.4
	6	A	4.5×10^{-3}	4.5
		B	3.6×10^{-3}	3.6
		C	1.9×10^{-3}	1.9

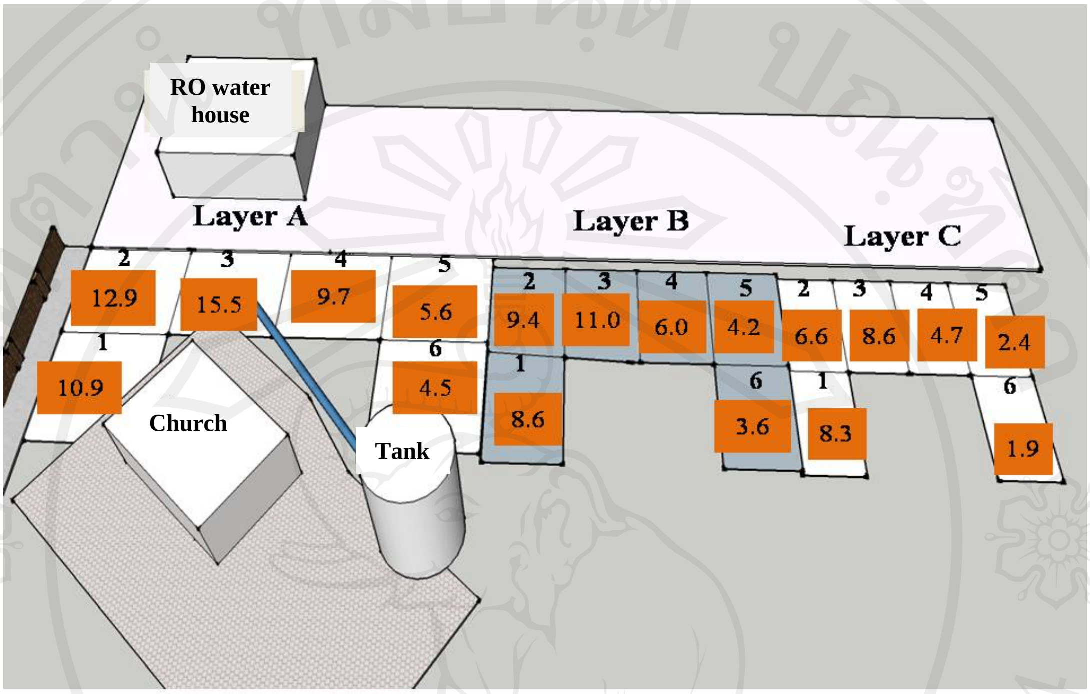

Fig. 3.7 Distribution of fluoride (mg/kg) at each soil depth according to soil sampling positions (orange band) of Ban Mae San Pa Daed

3.4.3 Soil collected from Ban San Makrut

The soil type at this location is different from the previous two villages. It is the mixed soil series of alluvial soil which is a mixture of loamy and sandy soils. Thus the flow of fluid from top down to the bottom can occur in a faster fashion causing the accumulation to be more in the lower depth as presented in Table 3.4 in the order of C > B > A. The ranges of fluoride accumulation in the soil at different discharged points and depths are as follows, 8.6 to 21.0 mg/kg, 11.6 to 19.8 mg/kg and 15.1 to 28.2 mg/kg, respectively (Fig. 3.8)

Table 3.4 The fluoride content in soil sample for each layer of Ban San Makrut

Location Villages/Districts	Positions	Layers	Fluoride content in soil 1 g (mg)	Fluoride content (mg/kg)
Ban San Makrut Tambon Ban Pan Amphoe Mueang	1	A	21.0×10^{-3}	21.0
		B	18.6×10^{-3}	18.6
		C	28.2×10^{-3}	28.2
	2	A	19.1×10^{-3}	19.1
		B	19.8×10^{-3}	19.8
		C	21.2×10^{-3}	21.2
	3	A	18.3×10^{-3}	18.3
		B	19.3×10^{-3}	19.3
		C	19.8×10^{-3}	19. 8
	4	A	8.6×10^{-3}	8.6
		B	11.6×10^{-3}	11.6
		C	15.1×10^{-3}	15.1

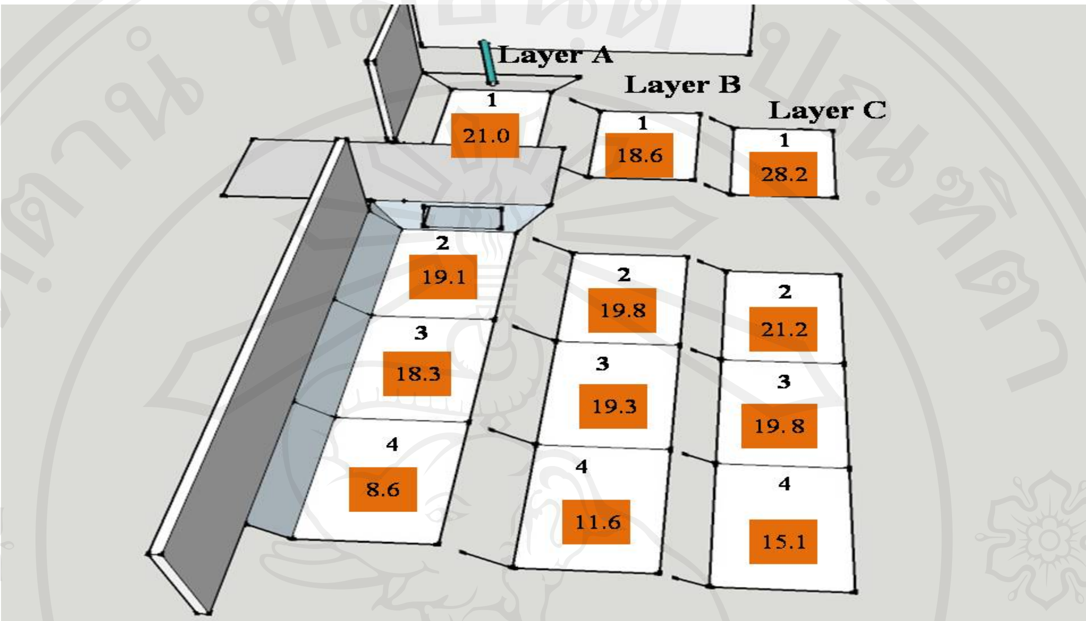

Fig. 3.8 Distribution of fluoride (mg/kg) at each soil depth according to soil sampling positions (orange band) of Ban San Makrut

3.4.4 Soil Collected from Ban San Phrachao Daeng

The soil from this location is classified as San Sai Soil Series which is a mixture of loamy and sandy soil as well. Its characteristic is therefore like the soils at Ban San Makrut which has a good water drainage capability with a good permeation of water and fast flow of surface water. Likewise, the fluoride accumulation in the soil at different depths occurred in the same fashion, that is more accumulation of fluoride was observed at the lower depth as seen in Table 3.5 with the order of C >B >A. The distribution of fluoride was diminished along the distance due to the sampling positions is near to a small waterway and surrounded by some constructions (Fig. 3.9)

Table 3.5 The fluoride content in soil sample for each layer of Ban San Phrachao Daeng

Location Villages/Districts	Positions	Layers	Fluoride content in soil 1 g (mg)	Fluoride content (mg/kg)
Ban San Phrachao Daeng Tambon Huai Yap Amphoe Ban Thi	1	A	21.9×10^{-3}	21.9
		B	21.6×10^{-3}	21.6
		C	26.3×10^{-3}	26.3
	2	A	15.4×10^{-3}	15.4
		B	22.3×10^{-3}	22.3
		C	25.1×10^{-3}	25.1
	3	A	15.4×10^{-3}	15.4
		B	18.2×10^{-3}	18.2
		C	22.7×10^{-3}	22.7
	4	A	9.9×10^{-3}	9.9
		B	15.2×10^{-3}	15.2
		C	20.8×10^{-3}	20.8

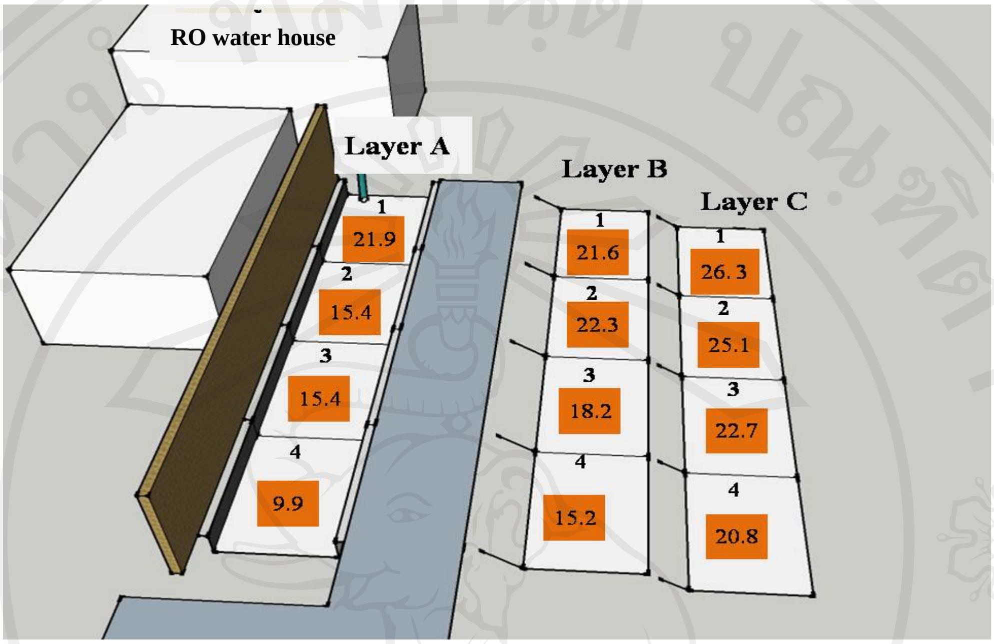

Figure 3.9 Distribution of fluoride (mg/kg) at each soil depth according to soil sampling positions (orange band) of Ban San Phrachao Daeng

3.4.5 Soil Collected from Ban Thi

The last water collection site is at Ban Thi. The soil collected from this location was classified as San Sai Soil Series as well. The accumulation of fluoride in each soil depth at different sampling points are as follows: layer A(0-20 depth) 12.1-88.7 mg/kg, layer B (20-40 depth) 16.9 – 90.0 mg/kg and layer C (40-60 depth) 17.4 – 100.2 mg/kg (Table 3.5). This indicates that more accumulation of fluoride occurred in the lower depth in the order of C > B > A which is obvious for the loamy and sandy soil characteristics. It was also observed that the content of fluoride present at the discharged point # 3 was more than other locations (Fig. 3.10). The distribution of fluoride at the locations # 3, 2 and 1 are more than the locations #4 and 5 due to the presence of a small waterway near the locations # 1, 2 and 3 caused the flow direction to occur in the opposite direction of locations # 4 and 5,

Table 3.6 The fluoride content in soil sample for each layer of Ban Thi

Location Villages/Districts	Positions	Layers	Fluoride content in soil 1 g (mg)	Fluoride content (mg/kg)
Ban Thi Tambon Ban Thi Amphoe Ban Thi	1	A	27.5×10^{-3}	27.5
		B	38.0×10^{-3}	38.0
		C	47.8×10^{-3}	47.8
	2	A	27.5×10^{-3}	34.1
		B	48.5×10^{-3}	48.5
		C	71.6×10^{-3}	71.6
	3	A	12.2×10^{-3}	88.7
		B	13.2×10^{-3}	90.0
		C	17.4×10^{-3}	100.2
	4	A	88.7×10^{-3}	17.0
		B	90.0×10^{-3}	24.0
		C	100.2×10^{-3}	34.2
	5	A	17.0×10^{-3}	12.2
		B	24.0×10^{-3}	13.2
		C	34.2×10^{-3}	17.4

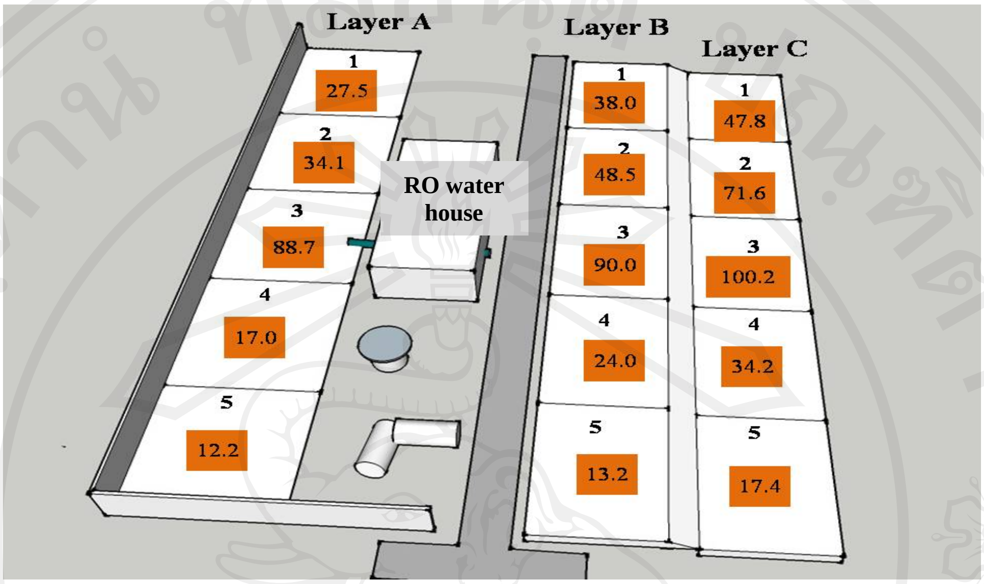

Fig. 3.10 Distribution of fluoride (mg/kg) at each soil depth according to soil sampling positions (orange band) of Ban Thi