CHAPTER 1

INTRODUCTION

1.1 The use of fertilizers

One of the biggest problems in the world today is the population explosion. Efforts have been made to ensure that enough food is available to feed the increasing population. Food is essential for life. Maximum crop growth can only be obtained when nutrients are added to the soil. To increase nutrients in the soil, fertilizers are needed. The rate of using fertilizer in the world during 1972 to 1982 is shown in Table 1.1. A fertilizer is an important material added to soil to supply essential elements for plants. Fertilizers usually refer to chemical fertilizers that contain nitrogen, phosphorus and /or potassium in the compound forms that plants can absorb.[1]

Thailand is one of the seventeen countries where food is produced to feed the population of the world. So soil in this country has been used for planting for a long time. Therefore the fertility of the soil decreases. It is then necessary to add fertilizer for increasing some nutrients in the soil. Thailand has been reported to be one of fifteen countries in the world where a lot of fertilizers are used.[2]

Table 1.1 Rate of using fertilizer (kg/ha) in the world from 1972 to 1982.[3]

Country	1972	1979	1980	1981	1982
New Zealand	1,319.5	1,206.0	1,017.7	1,021.1	946.8
Japan	389.5	477.7	372.1	387.2	412.1
North Korea	176.2	336.0	325.5	348.6	338.3

Country	1972	1979	1980	1981	1982
South Korea	288.9	385.7	375.7	351.3	281.7
China	45.5	130.3	154.6	150.1	157.5
Malaysia	35.5	101.1	105.1	92.3	102.1
Indonesia	28.9	44.1	63.0	74.4	75.0
Pakistan	22.8	48.6	49.5	53.1	61.6
Sri Lanka	48.7	68.2	77.0	76.9	71.3
Bangladesh	20.0	44.6	46.3	43.6	51.2
Vietnam	49.2	31.1	40.7	40.9	50.6
India	16.7	29.6	30.9	33.8	34.6
Philippines	25.6	34.6	33.7	32.4	28.8
Australia	26.1	29.1	27.7	27.9	23.7
Thailand	10.8	18.0	16.2	17.7	18.3
Myanma	4.6	9.3	10.0	16.5	16.7
Papua Newginea	11.8	15.1	14.8	32.6	15.1
Nepal	4.9	9.0	9.7	9.4	13.8
Mongolia	4.0	7.2	8.6	11.2	10.9
Cambodia	0.8	-	2.7	6.2	3.6
Laos	0.2	0.1	7.8	4.5	0.6

The quantity of fertilizers consumed in Thailand increases every year. Table 1.2 shows that from 1976 - 1990 use of nitrogen , phosphate and potassium fertilizers increased approximately 52 %, 32.5 % and 15.5 % respectively.

Table 1.2 Fertilizers consumption in Thailand in 1976 - 1990 [4]

Year	Quantity of fertilizer (ton)	N	P_2O_5 (ton)	K_2O	Total NPK (ton)
1976	664,391	112,537	85,866	34,088	232,491
1977	792,024	134,156	102,361	40,637	277,154
1978	785,433	133,040	101,510	40,298	274,848
1979	827,204	140,115	106,908	42,442	289,465
1980	786,431	133,194	101,627	40,345	275,166
1981	894,542	151,140	116,265	45,763	313,168
1982	1,042,503	174,765	134,299	57,648	366,642
1983	1,272,041	233,388	154,044	83,701	471,133
1984	1,246,688	227,712	142,623	67,916	438,251
1985	1,250,000	252,900	124,999	55,663	433,562
1986	1,350,000	308,501	132,502	70,326	511,329
1987	1,548,765	342,784	148,344	96,245	587,373
1988	1,992,633	439,720	200,833	137,456	778,009
1989	2,297,733	494,923	188,823	117,793	801,539
1990	2,648,910	576,517	318,337	148,937	1,043,791

1.2 The runoff of fertilizers from agricultural land

Fertilizer nutrients can be lost from soil in three different ways: firstly, by drainage water percolating through soil, leaching soluble plant nutrients, secondly, by the inefficient return to the land of the excreta of stock and, thirdly, by the erosion of surface soil or the movement of fine soil particles into the subsoil drainage system.[5]

Table 1.3 Phosphorus and nitrogen entering the environment [6]

Source	Phosphorus millions of pounds/yr.	Nitrogen millions of pounds/yr.
Natural	245-711	1,035-4,210
Man-generated	686-1,015	3,990
- Domestic sewage	(387-446)	(1,330)
- Runoff from		
• Urban land	(19)	(200)
• Cultivated land	(110-380)	(2,040)
• Livestock area	(170)	(420)

1.3 Behaviour of fertilizer compounds in the environment

Nitrogen fertilizers are usually water soluble and the nitrate form is mobile in the soil.[7] During raining, nitrogen fertilizers readily transfer into the soil. Nitrogen is one of the nutrients that can be leached with seepage water or carried off in surface run off. The average nitrogen loss in runoff is affected by cropping system and crop residue management. In Nigeria it was found that losses of NO_3-N in the run off water in 1973 were 3.3 kg/ha from no-till maize and 0.04 kg/ha from mulched maize plots in one season.[8]

Phosphorus from fertilizers, in contrast to nitrate, reacts with soil constituents to form insoluble compounds that are immobile in soil. Movement of phosphorus from agricultural land is primarily with the soil.[9] Erosion can carry phosphate adsorbed on soil particles into surface water. However there is little information concerning the dynamics of phosphorus movement from the tropical catchment. The amounts of phosphorus losses from runoff plots in tropical regions are as low as 0 to 2.0 kg/ha/season.[8] Phosphorus is removed from soil by crops and is also lost when surface soil is eroded.[10]

In addition to nitrogen and phosphorus, potassium losses are also of agricultural significance. Potassium behaves differently in the soil. The potassium ions may sometimes be incorporated from solution into the lattice of some clay minerals, but more usually they are available for plant uptake. Also movement through the soil is not so much influenced by the form of insoluble potassium compounds as by the electrostatic attraction to the negatively charged clay colloids. The exchangeable potassium can be taken up by the plant and while it can be replaced by other cations such as calcium, its mobility is limited and it tends to become re-adsorbed onto the clay colloids.[5,11] The mean concentration of potassium in a rain forest catchment was found to range from 0.43 to 1.55 ppm. In a study on Puerto Rican soil, absorbed potassium concentrations ranged from 0.01 to 2.29 ppm in runoff from a fertilized plot.[12] The average annual loss of potassium in runoff water and eroded soil in Nigeria ranged from 14 to 30 kg/ha.[13]

1.4 Impact of fertilizer to environment.

Fear has been expressed about pollution of natural water and reservoirs by high concentrations of nitrogen, potassium and phosphate nutrients resulting from the runoff from land treated with modern chemical fertilizer. Enrichment of surface water with nitrogen or phosphorus contributes to excessive algal bloom. Nitrogen as nitrate, which may be leached out to surface or ground water, can be harmful through human and animal consumption. A relatively small quantity of phosphorus in water runoff can be a major source of eutrophication and pollution of surface water. [5,7,8]

When P and N as nutrients, which are normally in short supply, are added to an ecosystem, P plays the role of trigger factor. Micro-organisms which are often in the situation of lacking of phosphorus, will immediately make use of the added nutrient and accelerate their rapid reproductive rate. They could quite suddenly become extremely abundant. Such a population explosion, usually involving one or more species of algae, is called a bloom. Since the blooms are photosynthetic, the oxygen level in the water during the daylight hours is sharply augmented by oxygen from photosynthesis. But during the night when there is no photosynthesis, to respiration which consumes oxygen may cause the oxygen content of the water falling below the level necessary for respiration of higher forms of animal life; fish kills often result.[14]

During an inquiry by the Commission for the European Community, it was mentioned that in eutrophic lakes, the amount of mineral nitrogen was equal to 0.3 mg/l. The lower limit of eutrophic water is estimated at 0.03 mg $P(PO_4)$/l. In the runoff water and in streams of agricultural regions, the concentration of total P reaches 0.1 mg $P(PO_4)$/l and, in urban areas, 0.2 to 1 mg $P(PO_4)$/l.[15]

Nitrogen is more likely to be leached than either phosphorus or potassium because of the mobility of the nitrate ion. Nitrogen fertilizers are readily converted into nitrate ions which are soluble and these pose serious problems. Nitrate is toxic because it can be reduced to nitrite in the stomach which can cause methaemoglobinaemia described as the condition in which the ferrous ion of blood haemoglobin is oxidised to ferric ion. This reduces the amount of oxygen which the blood can carry. In normal blood 1 % (adults), or 2% (children), of the haemoglobin occurs as methaemoglobin .[16]

Methaemoglobinaemia is not very common; there were 320 cases reported in infants drinking high nitrate well water in the United States between 1934 and 1950, whilst in West Germany, 700 cases were reported during the period 1956-1964. However, there appear to be few data for the incidence of methaemoglobinaemia in the developing countries .[17]

In a preliminary survey of nearly 200 infants (under 12 months) living in an intensively cultivated area of Sri Lanka where ground water nitrate concentration generally exceeds 20 mg N/l, 80 % of the infants had elevated levels of methaemoglobin in their blood although only one infant show clinical symptoms. The high ground water (the only source of drinking water) nitrate concentrations were thought to be the principal cause.[18]

1.5 Soil erosion

Soil erosion is among the most chronic environmental and economic burdens. Huge amounts of nutrients in soil are being lost. Worse, the soil accumulates in rivers, reservoirs, estuaries and other waterway where it is unwelcome. Erosion is thus a double disaster : a vital resource disappears from where it is desperately needed only to be dumped where it is equally unwanted.

Sediment, the product of erosion, is widely regarded as the major pollutant entering streams, lakes, and estuaries. The mass of sediment far exceeds that of any other pollutant, and it is clearly the single biggest pollutant from agriculture land. In 1977, erosion rates in the U.S. exceeded 22 ton/ha on 19 % of the land used for row crops in the midwest and on 32 % of row cropland in the Southeast.[19]

Thailand soil is currently deteriorating at an unacceptable rate that has reached a critical stage. Statistically, one third of the country, equivalent to 107 million rais (17 million ha, 1 ha = 6.25 rai) has been seriously affected by soil erosion. One of the serious problems is devastation of forest lands in the high plain or mountainous areas owing to the cultivation of short term crops without appropriate preventive measures against soil erosion.[20]

1.6 Vetiver grass

The handbook of World Bank describes the use of vetiver grass as the best known plant, at this time, that can be used to help prevent soil erosion and increase soil moisture content. The vetiver grass should be planted around or on cultivation plots, in one or two contour lines. When inter-cropped with field crops, it helps preserve moisture in the soil and absorbed nitrogen and helps prevent toxic and other chemicals from flowing into rivers and canals.[19,21] Some earlier studies indicated that vetiver grass treatments were more effective in reducing soil loss and runoff than hedgerows with no vetiver. [22]

1.7 Flow injection analysis for soil and agricultural product

Flow injection analysis which is a relatively new continuous technique can serve for routine analysis. Whichever automated system has been adopted in soil and plant testing or soil research, the experience has invariably been that both sample throughput and the quality and reproducibility of the data obtained are generally superior to that which could be obtained normally by traditional methods. Also a flow injection analysis method is safe and requires fewer personnel.[23]

1.8 Purposes of the study

This study has been undertaken with the following objectives:

1. To assess fertilizer residues in highland cultivation with and without vetiver grass.

2. To evaluate the use of vetiver grass in preventing environmental problems due to fertilizer residues and soil erosion.

3. To apply flow injection analysis to soil and agricultural products.