he Study on the Countermeasure and Impacts of Heavy Materials in Soil

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Abstract: The research was undertaken at Salakham Marsh to assess the countermeasure and the impact of heavy materials in soil**.** Soil sample analysis was carried out by spectroscopic technique and pHmeter. Results indicated that As, Cd, Cu, Ni, Pb, and Zn were main heavy elements that contaminated the soil in salakham marsh with pH ranges between 4-6 mg kg^{-1} which makes the soil to be very acidic. Based on these results, different solutions can be demonstrated to avoid heavy metals in soil. The erosion control verification and watershed regulation may be good strategies that can be applied in order to prevent an increase of heavy elements in Salakham marsh.

Keywords: countermeasure, heavy materials, pollution, sediment

1 Introduction

Heavy metals are natural components of the earth's crust. They are dangerous because they tend to bioaccumulate. Soil degradation involves both the physical loss (erosion) and the reduction in quality of topsoil associated with nutrient decline and contamination (Mupenzi et al., 2009). It affects soil quality for agriculture and has implications for the urban environment, pollution and flooding (Mupenzi 2010). Eroded soil damages many infrastructures especially in developing countries. In recent time, any discovery of contamination has increased dramatically as environmental science investigations have become more common for the redevelopment of ex-plant/factory sites forth commune search for ISO 14000 (SEIICHI et al 2004), aiming save the economic value of soil properties. Soil contamination cons-law was promulgated on 22 May 2002 and entered into force February 15, 2003 (SEIICHI et al 2004). In their study revealed that there is no single analytical method that can detect all components of microbial EPS, and say that there is a method commonly used to quantify EPS in sediments, which is the phenol-sulfuric acid assay. The primary goal of the Soil Contamination Countermeasures Law as revealed by Seiichi et al (2004) is to protect peoples' health for determining soil conditions and by providing countermeasures to prevent danger caused by soil contamination.

Several studies have investigated this problem where they affirm that the costs of damage to agricultural soil in England and Wales have been estimated as £ 264 million a year and the costs of treating water contaminated with agricultural pollutants as £ 203 million a year. Soil is being degraded as a result of pressure coming from nearly all economic sectors which are dominated by industrialization sector (Environment Agency, 2002; Samecka-Cymenman and Kampers, 2001; Mupenzi el al., 2010). It is also said that Heavy metal pollution of soil enhances plant uptake causing accumulation in plant tissues and eventual phytotoxicity and change of plant community (Ernst 1996; Zayed et al.1998; Gimmler et al. 2002). Face to the gravity of this problem which taking high level in most parts of Vientiane, our main objective was to analyze the soil contamination level in order to propose the methodology for providing countermeasures and prevent danger to population living in Salakham Marsh (That Luang)

2 Materials and Methods

Study site

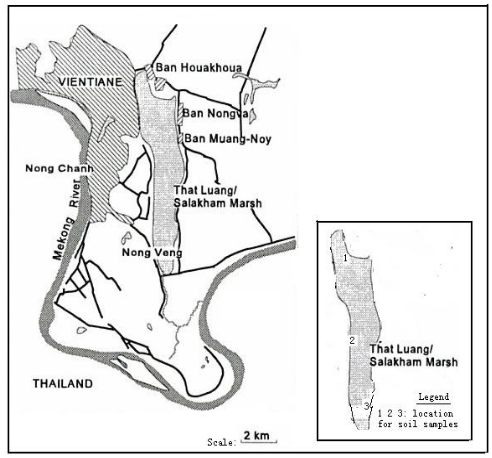

Figure 1 Mapping of the study area location

The Salakham marsh known under name of That Luang marsh is one of the largest wetlands located in peri-urban Vientiane with an area of 68 km^2. The main activity in this valley is agriculture where approximately half of its 2,000 hectares is under hoe cultivation. Also, Fish ponds are generally located along the margins of the marsh with an estimated of 15,000 people are involved with fishing-related activities on both commercial and subsistence levels (Coates, 2002). Other activities are affecting the wetland’s natural functions among them are: the construction a drainage canal through the swamp by the Vientiane municipality and the construction of a pumping station to remove water for paddy irrigation. The studies have shown that water quality have also indicated that seepage of saline groundwater into the marsh may be occurring which would have a dramatic impact on the marsh ecosystem.

Soil samples and pot experiment

Study was conducted on the soil samples, which were collected from the

Cd, Cr, Zn-loaded (270 kg/ha metals: CdSO4, K2CrO4, ZnSO4) plots in May 2010, we took soil samples by dryer on three locations in LUANG MARSH.:

The sampling techniques were broadly and free random chosen, implying almost homogeneous soils. To have representative soil samples from each sampled block, three small randomly dug holes were predicted using a Dutch (Eldman) auger. Sampling was replicated in some sites to allow for statistical analysis to determine repeatability of data. Sampling was carried at three different depths with different sizes according to the regulation: top or surface soil (0-20cm); middle soil (20-40cm) and sub-soil (40-60cm) (Mupenzi et al. 2010).on other hand , on pot experiment we tested Six plants (antirrhinum, erysimum, orache, radish,Sorrel and wallflower) which were sown and grown in a greenhouse and harvested between 45^{th}-60^{th} days after emergence, whereas growth rate and element content was determined. Note that this analysis was made after being air-dried and sieved it to 2 mm, the homogenized soils were watered to <70% of saturation water holding capacity. The samples were analyzed for soil pH, available soil nutrients organic carbon (C), Calcium (Ca), cupper(Cu), hydrogen (H), (Iron (Fe),total Magnesium (Mg), manganese (Mn), Nitrogen (N), organic matter, available phosphorus (P), Potassium (K), Sodium (Na) and zinc (Zn) were also analyzed

Estimation and testing (Statistical Analysis)

Mean values and Standard Deviation of the element contents were calculated, and analysis of variance (ANOVA) and Student's t-test (Box 1953; Murkowski and Eduard, 1990) were performed as follows:

$$x = \mu + \delta + e$$

Where

X= measured value; μ =true values, δ =systematic error bias and e = random error precision

The effects were estimated using direct formula by using the least squares approach (the outcome is the same). The first test of interest is whether there is a difference in the levels of the factor. It was compared:

*H*0: $\alpha_i = 0, \forall i$

Ha: at least one α_i is non zero

3 Results and discussion

Analysis of Elements and pH in Soil Samples

Soil sampling and analysis was then done on three selected zone areas. Major chemical elements identified in table 1 were analyzed using standard methods. Their physical, chemical and clay mineralogical properties are distinctive from those of soils, the soil in all three areas founded to be acidic

1 Analysis of major elements and their concentration in soil samples

samples	Type of major elements and their concentration (mg/kg)													pH
	N	P	K	Ca^{2+}	H^{+}	Na	Mg^{2+}	S	C	Fe	Cu	Mn	Zn	
1	1.24	56.2	0.23	1.56	26.4	0.09	0.52	20.2	18.2	2198	367	80	61	3.7
2	1.46	38.1	0.16	1.7	25.1	0.21	0.56	18.9	18.6	2871	360	110	80	3.6
3	1.33	10.1	0.19	1.57	20.2	0.12	0.45	19.3	18.9	2634	336	81	80	3.7
average	1.34	34.8	0.19	1.61	23.9	0.14	0.51	19.5	18.6	2567.7	354.3	90.3	73.7	3.6

Table 2 Analysis of relative values of the microbial respiration rate and the Fraction of labile humus

Soil treatment	Microbial respiration rate	Fraction of labile humus
+Cr	0.6***	1.41*
Cd	1.04**	1.21*
Zn	1.02**	1.39*

Table 3 Assessment of Cr , Cd and Zn concentrations (mg/kg^{-1} dry weight) in plant shoots

Plant species	Cr,Cd and Zn inmg/kg-1 (DW)					
	Control	Cr	Control	Cd	Control	+Zn
antirrhinum		0.58	0.22	0.62*	46	52
erysimum	0.73	0.82	0.22	3.11**	33	36
orache	0.47	0.72	0.48	1.26***	137	168*
radish	1.04	1.12	0.41	3.56***	85	129*
sorrel	0.71	1.16	0.38	2.71***		
wallflower	0.36	1.27*	0.23	1.43***	60	67

In this study (table 1), the following elements were obtained after analysis of samples taken from three samples such as: Fe, Cu, Mn, and Zn that presented a high concentration level. Other elements which were found after analysis are : H^+ and C with minimum concentration and the elements Ca and Na which presented a low concentration level.

The analysis of chemical characteristics of the soil which put in evidence the soil pH in these three locations revealed that the soils in most of the Luang Marsh areas are acid soil. This was supported by a studies from Mupenzi et al. (2010) and Mupenzi (2010) who showed that soil pH of 5.0 to 5.8 represents acidic conditions and is considered as optimal for some plant leaves such as tea. They attributed the acidic to many factors: First, the rock in which the soil came from; this hypothesis confirms the acidic of soil in most of Luang Marsh that belongs to the sedimentary rock. Secondly, the use of fertilizers with NO_3 in this marsh through agricultural activities that seemed higher and an increase of $Al^{3+}$and H^+ ions in soil which implied effects on the soil salinity. High salt levels in soils reduce the ability of plants to grow or even to survive and this was observed in last year's where the production was not satisfactory. The result has been a rise in groundwater levels, causing greater discharges to the surface. Wetland salinity occurs where irrigation practices have caused a rise in water table, bringing saline groundwater within reach of plant roots

As indicated in Table 2 and 3 the plant species grown in contaminated soil in some cases were higher than those of control plants; after the second flight analysis different methods of detection, it was noted the existence of a gap between the proportions of the "available" forms of metal and other heavy elements: the lowest values were found for the case of Cr, while values were the highest in Cd. It revealed only the heavy metal pollution had no significant effect in raising seedlings and plants. Actual concentrations and the influence of metals is a consequence of mobility, bioavailability and toxicity of both direct due on the Utilization of chemical fertilizers which increased in this valley. The results give more precision comparatively to other studies that have used measurement of colloidal carbohydrate fractions as a useful indicator of microbial EPS (extracellular polymeric substances) (Decho 1990) or / and a direct measure of the EPS itself (Yallop et al. 1994), and most of the techniques used to characterize the components of the EPS from laboratory cultures are not easily applicable to samples that come from natural sediments especially in marshland. When the acid is estimated phenol sulfuric assay most often used as a general method. As shown in table 2, the rate of basal respiration was inhibited by Cr and was analyzed by Cd and Zn ; it is shown that the effect of heavy metal pollution analysis influence the metabolism of soil microbes in all cases, and measurement show that plant may be responses to this system as analyzed have been slight. This confirms the Microbial basal respiration rate that was stimulated by treatment of Cd and inhibited by Zn and Cr

Conclusion

The results of soil sample analysis show that the pH of all samples collected from three locations is less than 6 which implies that the soil in Salakham Marsh is acidic. The concentrations of Cd, Cu, Ni, Pb, and Zn were main heavy elements contaminating soil in Salakham Marsh and their effects influenced the metabolism of soil microbes and the reactions of plants were less. The results confirm the Microbial basal respiration rate that was stimulated by treatment of Cd and inhibited by Zn and Cr.

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For preservation of soil and underground water for sustainable environment; the research on soil remediation associated to countermeasures may be the best solution.

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