



## Research Article

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# The Dynamic and Effect of Toxic in Acid Sulfate Soil, on Rice, in Mekong Delta, Viet Nam, Caused by the Artificial Actions

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## Abstract

Through a series of *in vitro*, greenhouse, field experiments with 4 iterations, with control variants, statistical processing of reliability we see: Toxicity in the environment in alum soil has very volatile Large and complex, this variation depends: 1-Applying three tons of CaCO<sub>3</sub>/ha to rice soil, otherwise washing acid sulfate soil some case and sometimes it is harmful. 3-Acid sulfate water with pH = 3.8 (Al<sup>3+</sup> < 480 ppm) can be used to irrigate rice. If it is contaminated with alum water with pH < 2.9, the soil will become alum after 5-6 days, 4-rice plant and, especially, the green manure cover reduce concentration of toxins. 5- Applying phosphate fertilizers can reduce toxicity in soil; 6-The correlation of toxic ions is a positive correlation, especially SO<sub>4</sub><sup>2-</sup> and Fe<sup>2+</sup>, Al<sup>3+</sup> and Fe<sup>2+</sup> So if we can limit one toxin, it can reduce other toxins that are correlated. In which, the most dangerous is Al<sup>3+</sup>, followed by Fe<sup>2+</sup>, then SO<sub>4</sub><sup>2-</sup>, the least toxic is Fe<sup>3+</sup>. Fe<sup>3+</sup> is toxic only in terms of physical but less toxic in chemical properties.

## Keywords

Toxicity, Acid sulfate soil, Rice plant, Mekong delta, Toxic ions dynamic, Impact of artificial factors

## Introduction

On acid sulfate soils, it is difficult for plants to live or survive with low productivity, mainly due to toxins in the environment. The toxins are both high in concentration and constantly fluctuating and very complex. One could say: It is a "quirky match" [1]. However, it still has its own rules for each poison or of a toxic group. Knowing that law, we can avoid harm and take advantage of it to arrange crops, fertilizers, irrigation, plant varieties,... To partly serve production and research. In another application, we present a portion of the results of our many years of research where each sub-category is one or a combination of studies or experiments. In turn introduce the agents: Volatility and characteristics of the volatility.

## Materials and Methods

### Soil

Undisturbed acid sulphate soil (not disturbed by cultivation): Soil is very acidic, with pH = 3.6-4.1; Al<sup>3+</sup> = 500-800 ppm, at this level, although the plants did not die, the toxicity was also very heavy. From there, people selected varieties resistant to alum, control varian: Neutral alluvial soil

in Tien River [2].

### Tree

Rice plant (good resistance to alum and poor alum tolerance, indicator tree (*Eleo Charis dulcis*) compared to wild land.

The contents of research and experiment: Find out about the fluctuations of toxic substances in the environment due to:

1. Apply lime (gradually increase the amount of fertilizer)

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compared with the control fertilization; 2-Due to flooded fresh water and dry water.

- Watering alum has different levels of toxicity; 4-Build the bed; 5-Due to rain; 6-do phosphate fertilizer; 7-Acidification of the original soil; 8-under alternating redox conditions; 9-Find the correlation between toxins.

- Arrangement of experiments in pots

Pot size: Diameter  $r = 30$ , height: 50 cm; material: Crockery, put in a greenhouse (Polyethylene) with 5 treatments (2 control variants), 4 replicates, layout: Sequentially the degree of toxicity: Gradually increasing.

- Field experiments:

Rice plants: On Nhi Xuan alum soil, plot: 25 m<sup>2</sup>, the soil remains intact, not plowed, experiment is done 4 times, repeated in random sequence.

In conditions need to maintain stable alum toxicity, use natural alum water to adjust.

- Norms of monitoring and analysis: 1-Growth and development of rice plants, especially stage 3-4 true leaves (rotten roots, black, poisoned stems-leaves,...). 2-Actual yield, and constituent indicators of productivity; and 3-Monitoring the growth and toxicity of Co Nang alum resistant control plant (*Eleocharis Dulcis*). Monitoring: According to the predetermined time and number of times). Analysis of soil and water environment: pH (Kaloman electrode), Fe<sup>2+</sup>, Fe<sup>3+</sup> (comparison of color of alpha dipyridine reagent), Al<sup>3+</sup> (Sokolov), SO<sub>4</sub><sup>2-</sup>, PO<sub>4</sub><sup>3-</sup> (Spectronic UV 120).

## Result and Discussion

### Fluctuation of toxins caused by liming

Many studies have come to the conclusion "liming for cultivation on acid sulfate soils as an indispensable condition" [3]. However, the amount of lime applied to a certain type of acidic soil, for a certain crop, in a certain season, will have a suitable fertilizer type and amount of lime. Normally, liming lowers "alum" (toxins), increases microorganisms, increases plant pH and yield. We try to see if that is the case in all cases. I arrange track in two types of soil:

With wet rice soils, the experiment was conducted in the field (Nhi Xuan commune), combining the experiment in a pot (green house) with two finishing methods: 1- no lime applied, and 2- fertilize 3 tons CaCO<sub>3</sub>/ha, with rice soil, after 15 days (with 2-3 cm of water on the field surface). Monitoring of toxins in two soil layers before and after liming, the results are in the following table (Table 1).

The Table 1 shows that: If applying 3 tons of CaCO<sub>3</sub> without immediately washing alum, the toxins will fluctuate as follows:

+ Fe<sup>2+</sup>: Decreased in both soil layers compared with no fertilizing, reducing about 800 ppm.

+ Fe<sup>3+</sup> and Al<sup>3+</sup>: The surface layer and the lower layer both increase but the surface layer is higher. Most worrying is that Al<sup>3+</sup> 899 ppm has exceeded safety limits. At this level, the rice dies, especially during the seeding period (3-4 true leaves). Compared with no fertilization, Fe<sup>3+</sup> is a little lower, but Al<sup>3+</sup> is 97 ppm higher.

+ SO<sub>4</sub><sup>2-</sup> both floors decreased and decreased rapidly in the surface layer. Compared with no liming, the amount of SO<sub>4</sub><sup>2-</sup> decreased more.

**Table 1:** Toxicity fluctuations caused by fertilizing 3 tons of CaCO<sub>3</sub> after 45 days (without alum washing) (ppm).

Deep (cm)	pH		Fe2+		Fe3+		Al3+		SO <sub>4</sub> <sup>2-</sup>	
	Before	After	Before	After	Before	After	Before	After	Before	After
Have fertilized 3 tons CaCO <sub>3</sub>										
0-20	3.9	3.4	1.901	1.064	374	1.560	792	899	3.888	1.857
20-40	3.5	5.1	273	155	578	1.134	1.168	1.192	3.840	2.438
Do not fertilize CaCO <sub>3</sub>										
0-20	3.9	3.6	1.901	1.981	374	1.324	789	802	3.870	3.890
20-40	3.5	3.2	270	355	570	1.144	1.068	1.098	3.856	3.868

**Table 2:** Toxicity changes caused by applying 1.5 g of CaCO<sub>3</sub>/1 kg of soil (potted test) (ppm).

Deep (cm)	pH		Fe <sup>2+</sup>		Fe <sup>3+</sup>		Al <sup>3+</sup>		SO <sub>4</sub> <sup>2-</sup>	
	Before	After	Before	After	Before	After	Before	After	Before	After
Have fertilized 3 tons CaCO <sub>3</sub>										
0-20	3.8	4.3	311	543	853	467	1.093	405	2.736	1.531
20-40	3.6	3.8	199	260	790	812	1.136	997	2.827	2.601
Do not fertilize CaCO <sub>3</sub>										
0-20	3.9	3.9	311	752	849	484	1.095	879	2.736	2.700
20-40	3.6	3.6	195	514	790	562	1.130	1.000	2.856	2.800

+ pH: Decreased in both layers.

Thus, if fertilizing three tons of  $\text{CaCO}_3$  without washing alum, it will increase the toxicity of  $\text{Al}^{3+}$ , because  $\text{Al}^{3+}$  has just been pushed out of the soil colloid by  $\text{Ca}^{2+}$ , increasing  $\text{Al}^{3+}$  in the soil solution (alum soil has a jarosite layer 25-30 cm from the ground). Thus, the liming at this level, if the  $\text{Al}^{3+}$  and  $\text{Fe}^{3+}$  alum is not washed due to the effect of lime, increasing the amount of toxins will not be beneficial and toxic to rice.

However, milder cases of alum may have different results. We arranged the same type of alum soil but made in pots with 0-40 cm intact layer flooded 5 cm and applied a large amount of 1.3 g  $\text{CaCO}_3$ /1 kg of soil, Monitoring results after 15 days (Table 2).

In conditions without much influence of the pyrite layer such as in the field and the amount of lime fertilizing is quite high, the effect of lime is clear, most of the toxins compared with no application are reduced ( $p < 0.01$ ).

Thus, liming must be combined with alum washing (at the level of 3 tons  $\text{CaCO}_3$ /ha, otherwise washing alum will not be beneficial). That is not to mention the very rare lime in the South. So, in order to increase the effectiveness of liming, it must be combined with alum washing.

### Fluctuations of toxins due to watering acid sulfate water rice

Soils of acid sulphate soil, winter-spring crop and summer-autumn crop often lack fresh water. People have used tidal water with 2 g/litre of NaCl to cultivate rice, rather than without irrigation. But the amount of alum water available in the canals can irrigate rice to save rice when drought or not (especially during drought) and the toxicity will be as follows: We have arranged an experiment to water 3 litres of alum water for a pot 2 cm deep enough, with different levels of alum (3 experimental recipes):

1: pH: 2.0;  $\text{Al}^{3+}$ : 900 ppm;  $\text{SO}_4^{2-}$ , 2 1.17%;  $\text{Fe}^{2+}$ : 1.500 ppm.

2: pH: 2.9;  $\text{Al}^{3+}$ : 1.252 ppm;  $\text{SO}_4^{2-}$ , 2 1.01%;  $\text{Fe}^{2+}$ : 1.300 ppm.

3: pH: 3.8;  $\text{Al}^{3+}$ : 486 ppm;  $\text{SO}_4^{2-}$ , 2 0.6%;  $\text{Fe}^{2+}$ : 650 ppm.

Water when the soil is just dry, let stand after 7 days,

take soil samples to analyse. Compare before age and control variant. The results are recorded in the following (Table 3).

When watering with alum pH = 2.0 or 2.9 or soil to flood this type of water, after only 7-10 days the soil has been contaminated with alum (in fact, we found that after 5 days, the soil was contaminated with alum).

If watering, alum has pH = 3.8, does not cause toxins in the soil to increase and soil pH does not change. At this toxicity level, it is not significantly toxic to plants [4]. Irrigation of alum buds with pH = 3.8 is still better than not growing because if not, the poison increases to the level of toxicity to the rice plant, plus the lack of water will cause the rice to die quickly.

The actual production in Nhi Xuan 1978, in Long an 1980 and some other regions showed that: When the rice is drought, use alum water with pH = 3.8-4.0 to irrigate the rice, the rice returns to normal, and some areas area without irrigation, rice dies quickly.

Note: When considering water for irrigation, attention should be paid to both the amount of toxins and their composition, especially aluminium.

### Phosphorus fertilization and the effects of phosphorus on toxins in the soil

Phosphorus is a very lacking factor in acid sulfate soil cultivation. To see its role in plants and directly with toxins in the soil; After that, in order to find out why the amount of phosphorus in acid soil is too lacking, we followed two subjects on sorghum growing and rice fields:

On sorghum growing paddy: The experiment was conducted in the field in the alum soil of Le Minh Xuan, in the rainy season, with different fertilizer formulas: 0, 30, 60, 90, 120 kg  $\text{P}_2\text{O}_5$ /ha (as super phosphate) on background: 40N + 30  $\text{K}_2\text{O}$  for sago Hegari. The results are recorded in the following (Table 4).

Through statistical processing found:

- Apply 30  $\text{P}_2\text{O}_5$  more than no fertilizer ( $p < 0.01$ )

- The jump of 60  $\text{P}_2\text{O}_5$  of new productivity increases clearly (if it is lower, it will not increase clearly) ( $p < 0.01$ )

Table 3: Variation of toxins in soil with irrigation of different types of alum water.

Toxins in soil (ppm)	$\text{Fe}^{2+}$	$\text{Fe}^{3+}$	$\text{Al}^{3+}$	$\text{SO}_4^{2-}$	pH
Land before watering (ppm)	32	193	567	2.145	4.3
Quality of irrigation water					
pH: 2.0; $\text{Al}^{3+}$ : 900 ppm; $\text{SO}_4^{2-}$ : 1.17%; $\text{Fe}^{2+}$ : 1.500 ppm	1.189	329	854	3.452	3.4
pH: 2.9; $\text{Al}^{3+}$ : 1.252 ppm; $\text{SO}_4^{2-}$ : 1.01%; $\text{Fe}^{2+}$ : 1.300 ppm	962	333	890	3.310	3.5
pH: 3.8; $\text{Al}^{3+}$ : 486 ppm; $\text{SO}_4^{2-}$ : 0.6%; $\text{Fe}^{2+}$ : 650 ppm	600	151	554	2.122	4.3
No watering	14	521	695	2.229	4.1

Table 4: Effects of dosage of  $\text{P}_2\text{O}_5$  on high yield of Hegari.

Quantity $\text{P}_2\text{O}_5$ (kg/ha)	0	30	60	90	120
Productivity (T/ha)	1.48	1.87	1.97	2.0	2.08

-  $\text{SO}_4^{2-}$  with  $\text{P}_2\text{O}_5$  has an inverse, tight correlation ( $r = -0.789$ ,  $p < 0.01$ ), while  $\text{Fe}^{2+}$  and  $\text{P}_2\text{O}_5$  are not correlated.

In wet rice soil: Diagram 1.10 shows that in the absence of phosphate fertilization:  $\text{P}_2\text{O}_5^{3-}$  inversely correlated with  $\text{SO}_4^{2-}$  ( $p < 0.01$ ) and inversely with  $\text{Al}^{3+}$  ( $p < 0.01$ ).

Thus, phosphate fertilization reduces toxins and vice versa when toxic increases  $\text{PO}_4^{3-}$  restriction. Particularly with  $\text{Fe}^{2+}$  and  $\text{SO}_4^{2-}$  under submerged conditions, both of these ions increase, perhaps fertilizing with phosphorus makes  $\text{Fe}^{3+}$  ( $\text{PO}_4$ ) 2 increases, these correlations are very tight with rice cultivation soil ( $p < 0.01$ ) and soil zero. Rice cultivation was less closely correlated ( $p < 0.05$ ).

Thus, the role of easy-to-digest phosphorus is very large because in acidic soils, phosphorus is very poor and has the ability to limit toxins. In fact, last year, in Lap Vo (Dong Thap), over 100 hectares of rice were contaminated. If urea fertilizer was applied, the rice would die quickly. Conversely, adding 50 kg of  $\text{P}_2\text{O}_5/\text{ha}$ , rice recovered quickly. Likewise, summer-autumn rice in Nhi Xuan applied 30  $\text{P}_2\text{O}_5/\text{ha}$ , saving rice rather than not fertilizing. In Cai Lay, Cai Be, people sprayed phosphorus on leaves when they got alum, then applied more 30 kg of  $\text{P}_2\text{O}_5/\text{ha}$ , rice yield increased by 1.5-2 times [5] (Figure 1).

## Effects of cover land plants and on fluctuations of toxins

The plants in our experiments, over four years of research, found: They have the ability to reduce toxins. Example:

Growing rice crops: Comparison of paddy land with non-cultivated land and land with turf:

- $\text{Al}^{3+}$ : Decreases rapidly after flooding, the content is lower and more stable.

- $\text{Fe}^{2+}$ : Lower content, decrease faster when submerged and return to equilibrium.

For legumes:

*Stylosanthes Gracilus*, *Americana Aeschinome* are plants not only decreased toxic in soil after three years of planting, but also decreased four months after planting, for example (Table 5).

On the other hand, monitoring the temperature during the March days, in topsoil, where there is a carpet (at 1 pm) is the highest but still lower than where there is no secondary carpet to 6-8 °C. The temperature difference causes strong alum removal in uncovered soil.

Since then, the planting of green manure cover, or other crops with cover is very necessary (right after reclamation), otherwise it will be acidification.

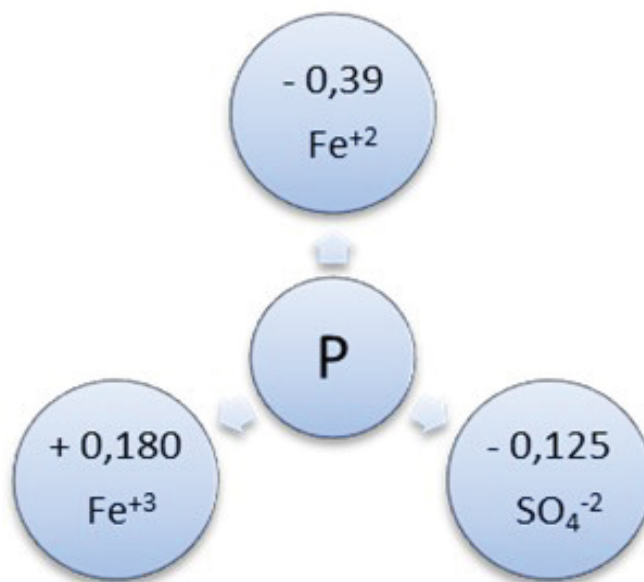


Figure 1: Diagram of toxic correlation with solubility on sorghum plantations.

Table 5: Effects of *stylosanthes Gracilus* and *A. americana* with  $\text{Al}^{3+}$  (meq/100 g).

Days	Control	Land for planting stylo	Land for planting A. americana
13 - 5	4.6	4.6	4.6
10 - 7	3.9	3.2	3.3
29 - 7	3.4	3.0	3.2
17 - 8	3.3	3.2	3.1
7 - 9	3.3	3.0	2.7

**Table 6:** Correlation (r) between toxins in acid sulphate soils in rice cultivation.

Poison pairs	SO <sub>4</sub> <sup>2-</sup> - Al <sup>3+</sup>	Fe <sup>2+</sup> - SO <sub>4</sub> <sup>2-</sup>	SO <sub>4</sub> <sup>2-</sup> - Fe <sup>3+</sup>	Al <sup>3+</sup> - Fe <sup>2+</sup>	Fe <sup>2+</sup> - Fe <sup>3+</sup>	Al <sup>3+</sup> - Fe <sup>3+</sup>
R	+ 0.478	+ 0.9776	+ 0.6830	+ 0.6018	+ 0.7177	+ 0.7359

(r 0.05 = 0.7440) (under no fertilization condition)

## Correlation between toxins in soil is much acidic

In the above sections, we have shown that the volatility is very complex, depending on many factors. However, that volatility also has a certain rule. In order to refer to one term, we process data for most experiments and give a correlation coefficient (symbol r) in the following (Table 6).

The table above shows: The toxins are usually positively correlated (r > 0). In which, it is worth noting that the pairs of SO<sub>4</sub><sup>2-</sup> with Fe<sup>2+</sup>: Correlated positively and very closely; Al<sup>3+</sup> with Fe<sup>2+</sup> is also positively correlated. That means when SO<sub>4</sub><sup>2-</sup> increases, Fe<sup>2+</sup> increases or vice versa. When Al<sup>3+</sup> increases, Fe<sup>2+</sup> increases and vice versa. From there, deducing the form of toxic ions in the soil is mainly in dissolved form SO<sub>4</sub><sup>2-</sup> base of Fe<sup>2+</sup>, and a little bit of Al<sup>3+</sup>.

Thus, if we have a certain effect on reducing a toxin it is possible to reduce the toxic when there is a positive correlation with it and will decrease when there is an inverse correlation between them.

## Conclusion

1. Toxins in the soil-water environment in acid sulphate soil have very large and complex fluctuations, this fluctuation depends on:
2. Applying three tons of CaCO<sub>3</sub>/ha to rice soil, otherwise washing acid sulfate soil some case and sometimes it is harmful.
3. Acid sulfate water with pH = 3.8 (Al<sup>3+</sup> < 480 ppm) can be used to irrigate rice. If it is contaminated with alum water with pH < 2.9, the soil will become alum after 5-6 days.
4. Rice plant and the green manure cover reduce concentration of toxins.
5. Applying phosphate fertilizers can reduce toxicity in soil.
6. The correlation of toxic ions is a positive correlation, especially SO<sub>4</sub><sup>2-</sup> and Fe<sup>2+</sup>, Al<sup>3+</sup> and Fe<sup>2+</sup> So if we can limit one toxin, it can reduce other toxins that are correlated.

## Declaration

### Funding

Please information: We do not accept funding from government or a good international organization. We self-search and contribute to our research.

### Conflicts of interest

We would like to say that our topic is not conflict with other

There are not conflict of interest between elected officials and corporate lobbyists.

Competing interests (include appropriate disclosures).

### Ethics approval (include appropriate approvals or waivers)

We also confirm that there is always a very good cooperation and cooperation between the group and outside the group, and no inconsistencies occurred during or after the end of this study.

### Consent to participate (include appropriate statements)

Consent to participate (include appropriate statement. We, all members of the group of authors agreed to cooperate closely and complement each other on knowledge and work.

### Availability of data and material (data transparency)

Availability of data and material (data transparency): The data we obtain and use in the Project is very transparent, very scientific, very objective.

### Code availability (software application or custom code)

Code availability (software application or custom code). The software used is also very popular and reliable.

## Author's Contributions

The individual contributions of authors to the manuscript should be specified in this section. Please use initials to refer to each author's contribution in this of section:

1. Ba Le Huy (Prof. Sci. Dr); Chairman, Science and Technology Council. His work is methodology and method and corresponding work.
2. Hoan Nguyen Xuan: (Asso.Prof. Dr); President of Hochiminh City University of Food Industry. His work is data collection and data analyze.
3. Nam Thai Van (Asso.Prof. Dr) vice the Centre of Hochiminh City University of Technology\_HUTECH. He responsible to perform research experiments in the laboratory as well as in the field.
4. Hung Le (MSCi) Natural Resources and Environmental Protection, Ho Chi Minh City. He responsible for content correction and grammar Vietnamese + English. Secretary of Project, Data basic collection, GIS, and RS Technology.

All authors read and approved the final manuscript, do not dispute interests, agree to act, unify ideas BECAUSE WE ARE KNOWLEDGE AND PRIVACY OF OTHERS.

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