Substantial soil arsenic-silicon dynamics under altered irrigation practices affecting rice plant anatomy

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Rationale

Physico-chemical parameters of agricultural soil play an important role in arsenic (As)-silicon (Si) mobility. We, to the best of our knowledge, are reporting for the first time, the effect of soil Si-As dynamics on rice plant internal ultrastructure. We are also proposing two parametric equations to determine the soil As release from the field during rice cultivation.

Procedures followed

Soil physico-chemical parameters (pH, ORP, TDS, OM, Conductivity), were measured and Pourbiax diagram was generated to determine the probable presence of the ionic form of soil Si-As in the aqueous phase. Concentration determination has been validated in soil-plant samples using XRF, ICP-MS and Synchrotron XRF to get the precise data. Si content was also cross-checked using a spectrophotometric method. Field set up was designed to maintain conventional water flooded (CF) and another periodically dried intermittent flooded (IF) condition to observe the dissolution pattern of soil Si-As under these two field conditions with same physico-chemical parameters. Real-time FE-SEM imaging was done to observe the changes in the internal vascular system in rice plants under these two irrigations and Si-As competition. Below are the proposed parametric equations-

$$\mathbf{A\,d\,C_S^{a2} = A\,h^a\,C_W^2 + A\,d\,C_S^{a1} + W^a\,C_r^a}$$ **and**

$$\mathbf{C_w^2(DP_s) = [\,AdC_s^{b1} + Ah^bC_w^1\,] - [\,AdC_s^{b2} + A(h^b\text{-}h^a)C_w^1\,]}$$

Results and Discussion

The proposed equations help to determine the elemental flux and release from field soil depending on irrigation practices. In the intermittently flooded field, the release of Si from soil Fe-oxyhydroxides was higher than in conventional fields. Also, the pH of agricultural soil within a range of 8-9.5 enhance the dissolution process of soil Si that suppress the translocation of soil As to the rice plant and this finally resulted in better internal structural integrity. In the continuous flooded grown plant, vascular systems are distorted due to high As stress and low Si accumulation.

[1] Bouman et al., (2005) Water Management, 74, 87-105. **[2]** Majumdar and Bose (2017) Nova Science Publishers, pp. 149-166.