Effect of Dust Fall in an Emerging Industrial City on the Growth of Eichhornia Crassipes

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Abstract. PM$_{2.5}$ is the focus of current research, but the dust fall seems relatively insignificant. The effect of dust fall on the growth of Eichhornia Crassipes was studied in this paper. Through macroscopic experiments, the apparent characteristics of Eichhornia Crassipes before and after dust fall, including weight increase, root length and leaf number, were studied. At the same time, the changes of pH value, TP and TN of Eichhornia Crassipes in water environment before and after dust fall were studied. The change of pH value was not significant, but dust fall strongly inhibited the absorption of TP and TN by Eichhornia Crassipes. The dust fall contains nutrients such as C, N, P, Cu and Zn required for plant growth, however, the positive effects of the nutrient elements provided by dust fall on the growth of Eichhornia Crassipes were smaller than the negative effects on the quality, root length and leaves of plants. The results of Evans blue staining showed that the cells of Eichhornia Crassipes were obviously damaged by dust fall at the cellular level. The heavy metals (such as Cu and Pb) in the dust fall may play an important role for the negative effects of this test.

1. Introduction
PM$_{2.5}$ is the focus of current research [1, 2], and more than 273,000 theses were found published in Google scholar. In fact, 2,970,000+ theses about dust fall [3, 4] were published, although PM$_{2.5}$ is more likely to be inhaled through the airways and into the depths of the lungs [5, 6]. Falling dust refers to the particles which are naturally settled on the ground by gravity under the condition of air environment, usually refers to the particles with a diameter of 10 µm -75 µm[7], including the discharge of industrial waste [8]. Articles concerned dust fall & vegetable about 122,000, dust fall & aquatic plant around 59,300, but less about dust fall & Eichhornia Crassipes.

Eichhornia Crassipes is an aquatic floating plant, mainly propagated asexually by stolons for many years, has strong ability to adsorb nitrogen and phosphorus and to accumulate heavy metals [9]. Eichhornia Crassipes has the characteristics of being warm and afraid of shadow, being fat and thin, being light and afraid of shadow. It has the characteristics of fast reproduction speed and strong pollution resistance. The growth speed of Eichhornia Crassipes in polluted water is about twice as fast as that of natural water [10], and it has strong acid and alkali resistance, it is considered to be an efficient and cheap plant for sewage purification, which is of great significance to eliminate and purify water pollution [10].
Thus, we hypothesized that *Eichhornia Crassipes* can grow normally under dust fall. The effects of dust fall on the growth of *Eichhornia Crassipes* were studied by weight, root length and leaf number of the plant before and after dust fall treatment. The influence of *Eichhornia Crassipes* on the growth of water hyacinth was studied by using the pH value, TP and TN of water environment before and after the dust fall treatment. Finally, the effect of dust fall on the growth of *Eichhornia Crassipes* at the cellular level was studied by Evans blue staining [11].

2. Experimental Section

The *Eichhornia Crassipes* was collected from the village of Cai in Erhai Lake, China, and the dust was collected from residential buildings in the Qilin district of Qujing, China. Qilin district is rich in coal resources. Guikun railway, Kunqu, Qulu, Qusheng expressway and Yunnan-Guizhou freeways meet here, convenient transportation. It is a cigarette, automobile manufacturing, machinery, metallurgy, building materials, textile-based emerging industrial city.

In sunny and dry weather for more than three days, choose clear and windless weather with a brush and shovel in the building above the windowsill sampling, at the sampling point to take 3 parallel samples. The samples were put into a clean self-sealing bag, and the sampling time and place were recorded at the same time. The samples were taken back to the laboratory through a 60 mesh sieve.

The collected *Eichhornia Crassipes* was cultured in the laboratory for a week to adapt to its environment, then 2 g was added to the leaves of *Eichhornia Crassipes*, and the root length, leaf number and quality of the plant were measured. At the same time, the total nitrogen (TN), total phosphorus (TP) and pH value of the water quality were determined weekly. Finally, the cell activity of *Eichhornia Crassipes* leaves was tested weekly by Evans Blue staining [12].

3. Result and Discussion

3.1. *Eichhornia Crassipes* form comparison

Figure 1 A and B shown that the *Eichhornia Crassipes* for non-dust fall had tiller more than for dust fall tests in figure 1 C and D. And the plant was bigger for non-dust fall by comparison figure 1 B and D. After the *Eichhornia Crassipes* was treated with dust fall, its leaves turned yellow, its roots rotted and the plants began to die (in figure 1 D). The dust fall had apparent negative effect on the growth of *Eichhornia Crassipes*.

![Figure 1](image)

**Figure 1.** Before and after *Eichhornia Crassipes* non-dust fall and dust fall test (A for before non-dust fall, B for after non-dust fall, C for before dust fall, and D for after dust fall).

3.2. *Eichhornia Crassipes* growth indexes comparison

In order to further understand the effect of dust fall treatment on the growth of *Eichhornia Crassipes*, the growth indexes of *Eichhornia Crassipes*, such as weight (in figure 2 and A in figure 3), root length and leaf number ( B in figure 3) were analyzed. During the 3-week dust fall treatment of *Eichhornia Crassipes*, the gross weight of untreated plants generally increased faster than that of treated plants (in figure 2). By means of experiments of 12 *Eichhornia Crassipes* plants, the gross weight of the plants treated with dust fall increased slowly, even appeared negative growth (No.12 in figure 2 B).
Figure 2. Dry weight of *Eichhornia Crassipes* non-dust fall and dust fall test (A for non-dust fall 3 weeks, B for dust fall 3 weeks).

From A of figure 3, it was found that the net gain weight of *Eichhornia Crassipes* without dust fall treatment was greater than that of plant with dust treatment. The maximum net gain weight of plant was 21.8 g and the minimum was 5.03 g in non-dust fall treatment, but the maximum was 12.43 g and the minimum of -1.3 g in dust fall treatment. The root growth of *Eichhornia Crassipes* increased in three weeks (B in figure 3), but the growth trend of dust fall treated *Eichhornia Crassipes* (3 mm-20 mm) was not larger than that of non-dust fall treated (20 mm-36 mm). The root of No.12 *Eichhornia Crassipes* treated with dust fall was rotted, so that the change of root length was 0 mm. The number of leaves of *Eichhornia Crassipes* without dust fall treatment increased by 3-5 mostly, the number of leaves of plants with dust fall treatment increased by 1 mostly, and the number of leaves of *Eichhornia Crassipes* No. 12 died, so the number of leaves did not increase. The tiller ability of *Eichhornia Crassipes* decreased after dust fall treatment, which led to the slow increase of its leaves.

When plant leaves were treated with dust fall, the photosynthetic capacity of plant leaves was decreased, and the net light, transpiration rate, stomatal conductance and intercellular CO₂ concentration during the growth period were lower than those of plant samples without dust fall [13], finally, the dust fall inhibits the growth of *Eichhornia Crassipes*.

Figure 3. Net gain weight (A), root and number of leaves (B) before and after *Eichhornia Crassipes* non-dust fall and dust fall test.

3.3. *Eichhornia Crassipes* external environment comparison

In order to analyze the factors affecting the growth of *Eichhornia Crassipes*, the contents of heavy metals (Pb, Cu and Zn) in dust fall were determined, and the pH, TP and TN of water environment were analyzed (Figure 4). Liu Chunhua et al had studied the dust deposition in Beijing and concluded that the heavy metals Pb, Cu and Zn mainly come from traffic pollution [14]. Cu and Zn are essential micronutrient for plant growth and play an irreplaceable role in plant physiological metabolism. The content of Cu²⁺ and Pb²⁺ is higher than that of soil background (A in figure 4); affect its absorption of nutrients (B in figure 4), on its growth toxic effect [15]. Lead is one of the main heavy metal elements
in soil. Plants will not be able to live normally and even cause plants death, the effects of Pb$^{2+}$ on the growth and antioxidant system of rape seedlings in the early stage of germination were studied [16]. It was found that Pb$^{2+}$ could displace Mg$^{2+}$, inhibit the chlorophyll synthesis, or accelerate the chlorophyll decomposition, and finally lead to the yellowing of leaves [6].

As can be seen from figure 1 to figure 4, the dust fall contains nutrients such as C, N, P, Cu and Zn required for plant growth, however, the positive effects of the nutrient elements provided by dust fall on the growth of *Eichhornia Crassipes* were smaller than the negative effects on the quality, root length and leaves of plants.

3.4. *Eichhornia Crassipes* Evans blue tests

In order to observe the effect of dust fall on the growth of *Eichhornia Crassipes* at the microscopic (cellular) level, the leaves of the plant were tested by Evans blue staining (figure 5). The area of *Eichhornia Crassipes* leaves dyed blue increased with the time of dust fall treatment. The area of leaves dyed blue was very small in the first week (A in figure 5), and most of them were dyed blue in the fourth week (D in figure 5) [11], the damage to the cells in the leaves of the plant increased, and Evans blue entered the cells to bind to the protein, increasing the area of the blue protein complex [12]. The damage of *Eichhornia Crassipes* leaf cells may be due to the large amount of dust fall on the surface of plants leaf, which affects the photosynthesis of *Eichhornia Crassipes*, and the damage of the plant leaves in the presence of heavy metals in the dust fall, *Eichhornia Crassipes* leaves photosynthetic rate decreased, tissue water shortage, stomata closed, chloroplast damage, related enzyme inactivation denaturation, resulting in cell and tissue death [13].

4. Conclusion

The results of this study indicated that the dust fall treatment of *Eichhornia Crassipes* reduced the absorption of nutrients, and led to the growth and development of the plant was inhibited, such as...
weight gain, root growth and tillering slowing down, macroscopically. At the cellular level, the
damage of the leaf cells of *Eichhornia crassipes* was aggravated with the increase of the time after the
dust fall was applied. The heavy metals in the dust fall may be responsible for the negative effects of
this test.

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