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Assessment of macro and micro nutrients around brick kilns agricultural environment

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A B S T R A C T

Brick kiln is well known as one of the main sources of air pollution; however, the pollutants produced from it do not remain in the air, they ultimately fall down to the soil and pollute the surroundings, therefore, this study was carried out to assess the status of macro (N, P, K and S) and micro nutrients (Fe, Mn and Zn, Cu) in the agricultural environment near the brick kilns of Young Brahmaputra and Jamuna Floodplain soils. Composite soil and plant samples were collected from four distances such as 250 m, 500 m, 1000 m, and 1500 m in three different sites. Sulphur (2352–3378 mg kg^{-1}), Zn (86–156 mg kg^{-1}) and Cu (24.7–46.9 mg kg^{-1}) are found in the elevated levels near brick kiln soils that is released due to burning of poor quality coal and fire woods. The alarming news is that plant uptake of S and micro nutrients in the nearest areas of the brick kilns are significantly higher than the areas far from the brick production and their concentration ranges from 23 mg kg^{-1} to 101 mg kg^{-1} for Zn, 10–41 mg kg^{-1} for Cu, 35–1309 mg kg^{-1} for Fe, 26–126 mg kg^{-1} for Mn and 2590–mg kg^{-1} for S. Data indicates both soil and plant received maximum amount of micronutrients and S concentrations within 500–1000 m distances from brick kilns. Iron and Mn concentrations vary within a permissible limit but the plant uptake is high. Nitrogen concentrations is increasing with the distance from the brick kilns in both soils and plants but no definite pattern of P and K accumulation was found. Research suggested avoiding agricultural practice nearby brick kiln soils due to micronutrient contamination in order to preserve adjoined agricultural environment.

1. Introduction

Brick is considered as one of the most precious building materials of modern civilization. Due to low price it remains nearly no alternative for today's booming construction industries, besides this, higher cost benefit ratio makes brick very much popular in third world countries like Bangladesh with a population of nearly 160 million [1]. To accommodate this huge population, nearly 6000 authorized and numerous unauthorized brick kilns are in operation in Bangladesh [2] which are mostly fired by coal or wood [3]. Due to poor technology and the improper burning of coal and wood produces a lot of pollutants during the brick production, among them CO_2, CO, SO_2 and other green house gases are the most common ones [4]. Heavy metals, such as, Pb, Hg, Zn, Cu, Ni, Se, Fe, Cd and As are also found as a byproducts [5]. Another important and alarming byproduct from brick production is fly ash

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which contains a wide range of toxic materials; among them, high concentrations of K, Na, Zn, Mg and Fe are found [6]. Fly ash doesn't stay in the air for the life time; they ultimately fall down to the soil and may be taken up by standing plants.

During brick production, some necessary elements are produced as a byproduct, such as Fe, Mn, Zn, and Cu and considered as micro nutrients for plants. Without these elements, plants cannot grow properly and show deficiency symptoms [7]. A lack of these elements in younger and older leaves show deficiency symptoms and higher level chlorosis may occur [8]. Besides these, SO_2 and NO_2 are also produced as a byproduct during brick production when the bio fuels are burnt. Sulphur depend on its chemical form can be a highly reactive element suggested to influence metal pollutant mobility and nutrient cation availability in soils [9,10]. Since many toxic metals bind strongly to certain species of S (i.e., Pb, Hg), a mechanistic understanding of speciation dynamics in soils is needed [9]. Furthermore, an understanding of the factors controlling S reactivity in soil organic matter is vital to describe the S flux from soil, and as such, the transfer of S between soil and other reservoirs in the global S cycle. In addition, fly ashes are one of the important sources of K in soil near coal fired industries like brick kilns [6]. One of the important characteristics of micro elements are becoming toxic and behave likes a contaminant when they cross the maximum allowable limit, and can cause adverse effects on plant and soil [6]. Accumulation of these elements in soil depends on many other factors, such as properties and constituents of the soil [11]. The mobility of Fe, Mn, Zn, and Cu in soils are driven by three major factors such as specific adsorption to different solid phases, precipitation of sparingly soluble compounds and the formation of relatively stable complexes or chelates with the soil organic matter [12]. Like other metals, minerals grain size [13] and soil pH has a very strong effect on the mobility of them in soil [14]. At high pH, these metals tend to be precipitate. Soil pH also controls the solubility of metal hydroxides, carbonates and phosphates, hydrolysis, ion-pair formation, organic matter solubility, as well as the surface charge of iron and aluminum oxides and clay edges [15]. Organic matter plays a vital role in metal accumulation in the top soil by forming chelates [16]. Several studies show that the nutritional degradation of the soils such as N, P, K, S, pH and EC etc among them most of the work was done to assess the burnt and unburnt areas of the brick kilns [11,12,17–19]. However, very little work has been done to assess the pollutants nearby brick kilns and their affect on plant and soil [5,20] but none has been done on the indications of macro and micro nutrients accumulation in soils and plants nearby brick kiln emissions. Therefore, the current research aims to find out the accumulation of macro and micro nutrients on brick kilns adjacent plant and soil agri-environment.

2. Materials and methods

2.1. Site descriptions

Three research sites (Mawna Gazipur, Kalampur Dhaka and Noyadingi Manikganj) were selected (Fig. 1a–d) on the basis of parent material, wind direction and vegetation. Medium high land was used because of its influence on cropping pattern and farming system (Table 1). Soil and plant samples were taken from the agricultural fields adjacent to the brick kilns which exposed to the different degrees of environmental pollution in February, 2014. Four distances such as 250 m, 500 m, 1000 m, 1500 m were identified based on the predicted brick kilns emission. At each point, a composite soil was collected from three different layers such as, surface (0–15 cm), subsurface (15–50 cm) and substratum ($50–100^{+}$cm). Plant samples were also collected from the respective field from where the soil samples were collected by uprooting 12 plants from each distance.

2.2. Laboratory analyses

Soils were extracted by Aqua regia with a ratio of 1:10 for total P, K, S, Zn, Cu, Fe and Mn concentrations and N is determined by Kjeldahl method. Available P, K and S were determined following standard procedure [21]. For the determination of available Zn, Cu, Fe and Mn, 1 N HCl was used as an extracting agent with a ration of 1:33 [22] and micro nutrients were analyzed by atomic absorption spectrometer. Phosphorus and S were analyzed by spectrophotometer and K was analyzed by flame photometer. The data was analyzed using statistical software strata version 12.

3. Results and discussions

3.1. Accumulation of macro and micro nutrients in soil adjacent to the brick kilns

In surface, subsurface and substratum soils of the study area are mainly silt loam in texture is favorable for agricultural practice, where clay percentage is <10% in most cases (Table 2) but organic carbon (OC) contents varies significantly with distances from brick kilns especially in 1500 m, indicating surface soil degradation nearby brick kilns. Organic matters of these fields may be burned out by intense temperature from 1600° to 2000° F. The heat wave continues to move to the adjacent fields and destroy the organic carbon of the soils also reported by several scientists [19]. The affected areas are expanding rapidly as brick production areas are increasing concurrently. Brick kilns are not only destroying large areas of agricultural lands, they are also reducing the agricultural production.

Soils are slightly acidic in nature in the sampling sites may be due to the application of excessive fertilizer and impact of nearby brick kilns. Brick kilns usually are emitting toxic gases, such as SO_2, NO_2 and some other compounds [24]. Sulphur di oxide is severely responsible for acid rain, which turns to lower pH. In addition, SO_2 may be dumped to the soil as mass flow and may be mixed with the water to produce H_2SO_3, which ultimately produce H_2SO_4, and lower the pH but it is increasing concurrently with the distances.

A primary source of macro nutrients (N, P, K and S) in soil is organic matter. Many processes like cultivation increase the rate of decay and oxidation of organic matter in soil [25], which in turn lowers the total N content in soil, as supply of