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Review Article

THE WAYS OF ACID ACCUMULATION IN KABUL BASIN SOILS AND ITS EFFECTS ON ANIMALS AND PLANTS, KABUL, AFGHANISTAN

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ABSTRACT
Kabul city is one of the most populous and crowded cities among the other cities of the world, as a result of this toxic gases are deposited in the atmosphere with soil pollution in Kabul. Apart from this mismanagement of Canals, garbage, unplanned house are the main reasons of accumulation of acids in the soil of Kabul. When these pollutants comedown from atmosphere alongwith the drought conditions, it spreads in the atmosphere and soils. These gases from atmosphere especially during spring season by acidic rains percolate in different soil horizons leaching out of this acid and washing along with water change the pH of the soil making it toxic at various places alongwith the ground water. The formation of acids and leaching into soil affect soil microorganisms, affects solution and coagulation of materials present in the soil as colloids. So it affects the soil flora and fauna or the biodiversity.

***Keywords**: Soil, Atmosphere, Acidic rains, Toxic Elements and Components, Acidification, Hydrogen Ions*

INTRODUCTION
The acidic and basic nature of soil depends upon the pH of the soil which in turn depends upon the chemical content present in it. It affects the chemical and physical characteristics of soils. Acidic and basic nature of the sold depends upon the elements and components that are present in the air and after rains, which are washed from the air and infiltrate the soils. Activities of some animal and different plants are affected by acidification of soils. Generally the acidification of soil due to acidic rain pollutes the ground water and negatively affect the microorganisms that are living in the soils. The soil acidification is more in humid regions and the acid leaches from one layer to another layer. The accumulation of acid triggers some chemical reactions in the soils leading to production of different kinds of compounds. The ground water movements among different aquifer layers by different speeds wash soluble materials from different layers. Industrial activities for example burning of coal and oil, burning of tyres/rubber for various uses adds to this pollution. All such pollution has resulted into health issues among the population of Afghanistan.

MATERIALS AND METHODS
A. Aim of the Research
The aim of this research is to select different factors responsible for soil acidification.

B. Location of Kabul City
The Kabul city about 3500 years ago was one village and after continuous developmental activity now it's the capital of Afghanistan. Towards the north of Kabul, is Kapisa and Parwan province, south is Logar and Nangrahar province, from east side Laghman and the west side is Wardak province having sharing their borders. Kabul province is located at 34.5º and 34º of N latitude, 68.8º and 69.2º E longitude. Kabul city is located between mountains, at an average 1800 m height from ocean level and the Sherdarwaza at the Gashed par is about 2218.5m (Safi, and Ghaffori, 2012, pp. 1-71).

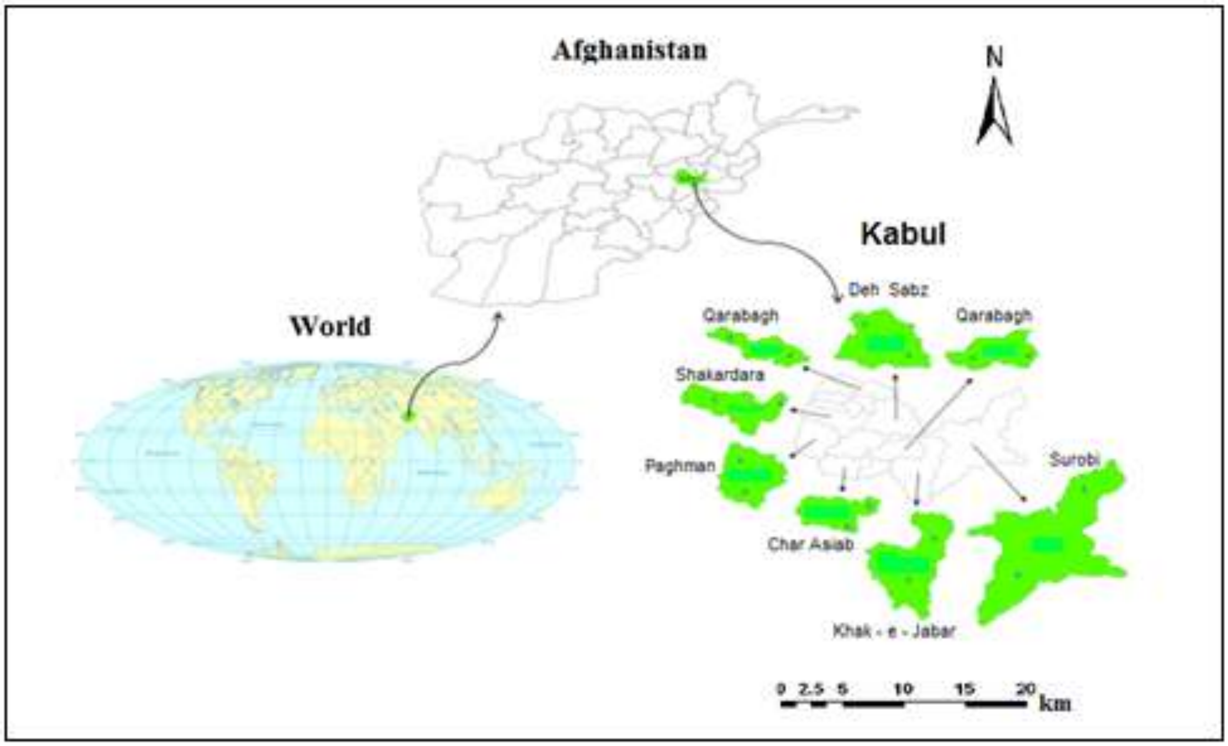

Figure 1: Location of Kabul province.

RESULTS

The main reasons of soil Acidification

The main reason of soil acidification is the culture of peoples, atmospheric pollution, mismanagement of garbage, different kinds of factories, raw vitrines, burning of plastics and use of coal in the houses for cooking.

Source of Acidic Rains

Industrial activities for example burning of Coal and oil in the factories, Vehicles, continuous melting of metals in the factories are responsible for different kinds of gases adding into the atmosphere (figure 1). Other sources of atmospheric gases consists of bread industry, burning tyres in the houses (Barrera - Bassols *et al.*, 2006). Generally these kind of gases consists of Sulfur dioxides and Nitrogen oxides, they form fog when they react with water and give rise to HNO_3 and H_2SO_4. These strong acids by rain comes down to earth surface as water or as snow. These may also get associated with the dry materials in the atmosphere like dust (Coulomb, *et al.*, 1996). Normally our atmosphere or the rain water it produces have a pH of about 5.5. But some time the pH of rain water comes down to 2.0 also (figure 2). The amount of acids transferred from industrial centers is also transferred to other part of the world via wind. This polluted air can get transported from east America, Europe, Centeral Asia and from east part of China (Wong, 1987).

These type of gases travel about 1000 km with the wind and form Sulfuric acids and Nitric acids at the different regions of the clouds. After that these type of gases by precipitation come down to the earth surface and gets combined with the soil component. This gives rise to H^+ and anions of

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SO_4^{2} and NO_3^- in the soils. The mobility characteristics of Al in the soil is very strong and as a result Ca and Mg are speedily displaced from soil by Al. The accumulation of Al takes place throughout the soil and also to the surface waters too (Wong, 1987).

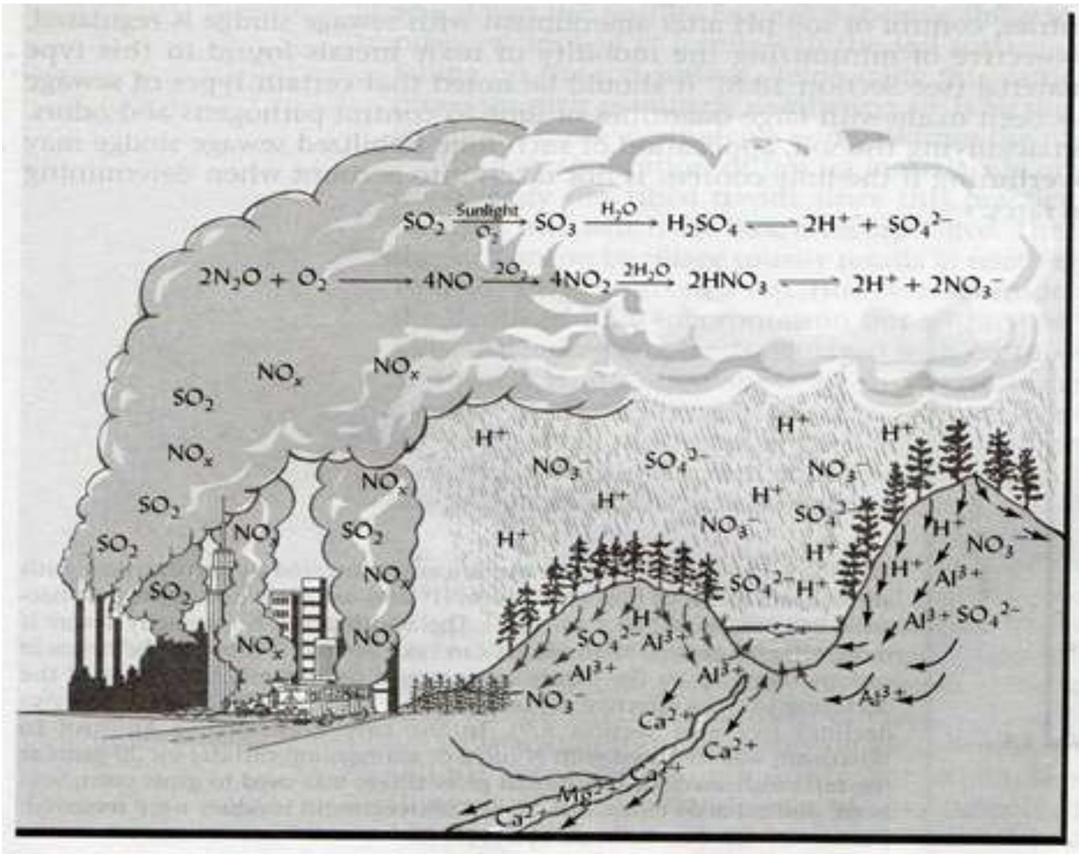

Figure 2: in this figure forming of acidic rains in the urban areas, belonging to the distance of flows in the drainage areas. This gases due to coal factories in the electricity products, different oils burning in the vehicles and its more N_2 and S gone to the atmosphere. Some experience showed that that about 60 % acids from sulfur gases and 40 % from Nitrogen gases forming (Sullivan *et al.*, 2006).

Various acids in Precipitation

After different types of precipitation bringing acids in the soil, pH of soil comes down, in generally to 5.6 from neutral 7.0. Between layers of atmosphere are found H_2SO_4, HNO_3, N_2, S, Volcanic ash, smokes, burnt plants smoke and fossils smoke (Wong, 1987). Sulfides and nitrites individually with H^+ are formed:

$$H_2SO_4 \rightarrow SO4^{2-} + 2H^+$$

$$HNO_3 \rightarrow NO_3 + H^+$$

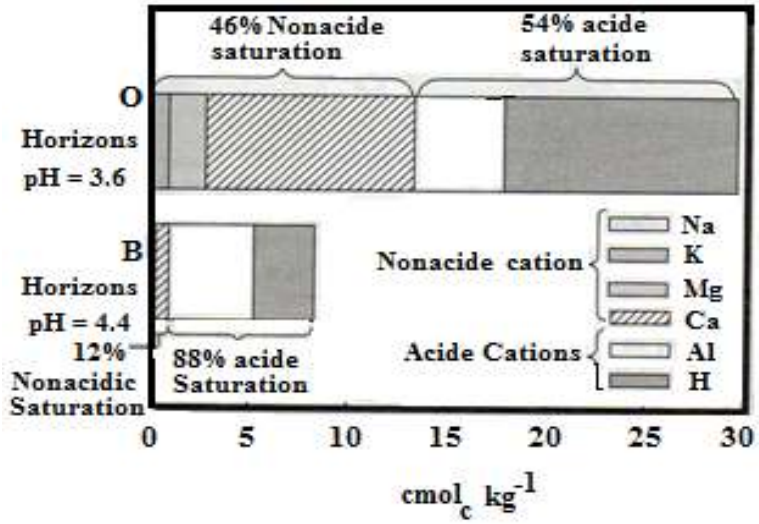

Figure 3: the saturation condition of Cation Exchange Capacity (CEC) acid and by others characteristics showed at the different soil. This data on the horizons of O - Horizon و B - Horizon more than 150 pedon and at the 144 watersheds applied. From this graph cleared that Cation Exchange Capacity (CEC) showed (Sullivan *et al.*, 2006).

Effects of Acidic Rains

The acid rain is responsible for weathering of expensive structures, ruining vehicles, adversely affecting the health of fishes in water and plants in forests (Wong, 1987).

The amount of Acid entering into the soil

This kind of rains in the north America occurs more and is ideal place to collect sample for acid rain. From the different experiences we found that in the one $1m^2$ in a year with 1000 mm rainfall, a pH of 4 has been recorded with amount of H in the every liter water was 0.0001 mol, in this case amount of H in one liter water was equal to (0.0001×1000 = 0.1 mol), mean that in the $1m^2$ area of soil the same amount of acidic rain from atmosphere entered. Amount of H^+ upto about 10 Cm to 20 Cm depth of soil horizon was found with the organic materials (O- horizon) alongwith sandy soil. Taking 50 kg sample from organic horizon showed $0.5mg/m^3$ concentration and when 140 kg sample was taken from sandy horizon E – Horizon, bulk density equal to $1.4\ mg/m^3$ was seen. In this case the type of soil is podzol soil due to too much acidic rain. When the pH of soil is 4 the Cation exchange in the O - horizons is very good and it's about equal to 50 c mol/kg and in E - Horizon equal to about 4 Cmol/kg (Vangronsled, *et al.*, 2009). From that we can find that the amount of acidic rain is 10 Cmol H^+/m^2 and is about equal to 0.4% O – horizons. The Cation exchange capacity is about 1.8 % in the E – Horizon. Input of acid and percentage of Cation Exchange Capacity (CEC) by acidic rain in the O - horizon can be cumulated by following formula:

Acidic input: 0.1 mol H^+/50 kg soil = 2×10^{-3} mol H^+ / kg = 2 m mol H^+/kg = 0.2 c mol_c H^+/kg

Percentage of CEC: (0.2 c mol_c H^+/kg) / (50 c $mol_{c\ CEC}$/kg) × 100 = 0.4%

Input of acids and Cation Exchange Capacity (CEC) by acidic rain in the E – Horizon by the following formula:

Acidic input: 0.1 mol H^+/140 kg soil = 7×10^{-4} mol H^+ / kg = 0.7 m mol H^+/kg = 0.07 c mol_c H^+/kg

Percentage of CEC: (0.07 c mol_c H^+/kg) / (4 c mol_c CEC/kg) × 100 = 1.8 %

The amount of H+ by acidic rains input to the soil, (figure 3), the amount of Ca belonging to the mother rocks weathering and minerals of soil that which amount Ca and others elements exchange. Generally the amount of acidification related to the amount of H+ that exceeds from the normal range (Su *et al.*, 2014).

Soil Acidification

When strong acids of Al which are mobile and get exchanged with the air, atmosphere and soil more leaching of Ca^{2+} ions takes from the soil. The more percentage of more acidic anions in the soil SO_4^{2-} and NO_3^- play an important role in leaching of Ca^{2+}. The ions of H^+ and Al^{3+} show a very highspeed exchange than Ca^{2+} (Raskin *et al.*, 1997). The saturation of acid cations and complex exchange during 28 years is shown in the (figure 4).

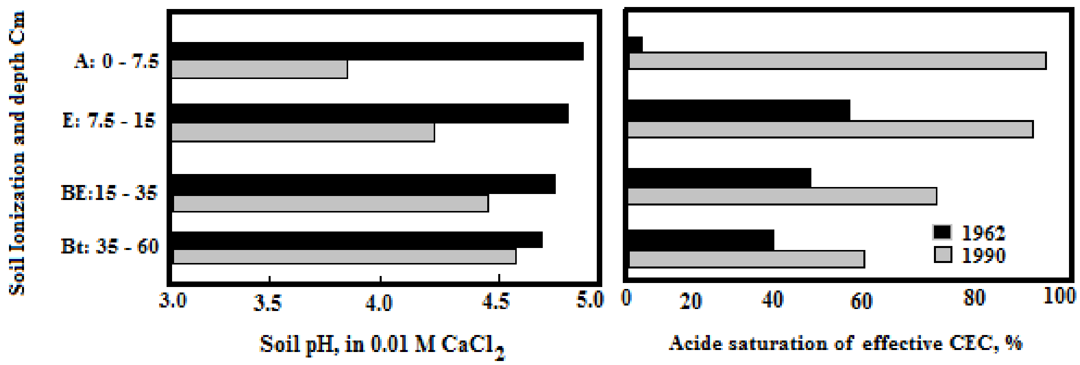

Figure 4: there showing two kind of exchange acids in the profile at the duration 28 years at the different type of plants. This at the upper horizon O – Horizon taken. There is from more lime and salts plantation is not possible.

The recent and previous studies showing that the amount of soil acidification in soil is natural and in ecosystems is to now not cleared. The different studies showing that in generally accumulation of acids in the soil is 30 - 80 %, the more percentage in the humid regions by acidic rains occurring (Prasad and de Oliveira, 2003).

The steps of soil acidification

Acidic and basic conditions of soil depend upon amount of H+ in the soil (Pandolfo, 2012).

Generally this process in nature occur continuously (figure 5). These type of data we got from the O – Horizon and B – Horizon taken, its more than 150 pedons in the 144 watersheds. In the O – Horizon about 90 % from organic materials was making acidic pH and between them acidic cations of H^+. But in B – Horizon about 90 % was minerals particles and its pH is medium and about 88 % saturated with acidic materials. Here amount of cations were more particularly Al (Modified from Sullivan *et al.*, 2006).

The types of soil acidifications

Generally in the soil three type of acidification can be seen, they are active acidity, salt acidity or exchangeable acidity and residual acidity. The active acidity is from H^+ ions in the soil solution , salty acidity belonging to the H^+ and Al and due to cations exchange with KCl and Residual acidity, this type of acidity is there generally by limestone and another volcanic materials.

Soil Sensitivity vs Acidifications

Soil acidification is due to building up of hydrogen cations, this reduces the soil pH. normally, this happens when a proton donor gets added to the soil. This donor can be an acid, such as nitric acid, sulfuric acid, or carbonic acid. It can also be a compound like aluminium sulfate, which reacts in the soil to release protons. Acidification also occurs when base cations like calcium, magnesium, potassium and sodium are leached from the soil (Negri *et al.*, 1996).

Figure 5: showing the device of pH in the laboratory of Kabul university, Geoscience faculty, department of geology, in this procedure 5g soil (smaller mm sieving passing samples) in the Biker solution and we can find the amount of H+ and OH in the soils.

pH, acidification and basic of soil

Generally the soil is in the area are acidic soil, neutral soil and basic soil based on the amount of H^+ and OH^- determined (McCutcheon and Schnoor, 2003) (figure 5).

$$H_2O \rightarrow H^+ + OH^-$$

The sources of Hydrogen Ions

When the CO_2 comedown from the atmosphere and combines with water in the soil, more H+ ions are produced in the soil. As well as when the plant roots are decomposed by microorganism also then more CO^2 and H^+ are produced in the soils (Man, et al., 2013), this condition we can see at the following equation:

$$CO_2 + H_2O \rightarrow H_2CO_3 \leftrightarrow HCO^{3-} + H^+ \qquad pk_a = 6.35$$

Generally H_2CO_3 is a weak acids and it having pka 6.35 (negative logarithm and its same to that of pH, at the equilibrium condition). At this time more ions of H+ spreads in the solution, when pH is lower from 5 in this case more organic materials also present and other particles of microorganism add input to the soil mass. Some of this organic acids having lower equivalent, like Citric acids or Malic acids very easily separated from soil solution. But some time very strong acids like Carboxylic acids and Phenolic acids, produced by garbage and enters into the soil. This reaction (general groups of Carboxic acid) can be shown by following equation (Lai, 2011):

$$[RCH_2OH) + O_2 + H_2O \leftrightarrow RCOOH^- \leftrightarrow RCOO^- + H^+ \qquad pk_a = 3 \text{ to } 5$$

Pka is Carboxylic acid and its between 3 to 5 depending upon the characteristics of soil structures, other group of organic materials is phenolic acid and have a very high pH (Khokhar, *et al.*, 2012), (figure 6).

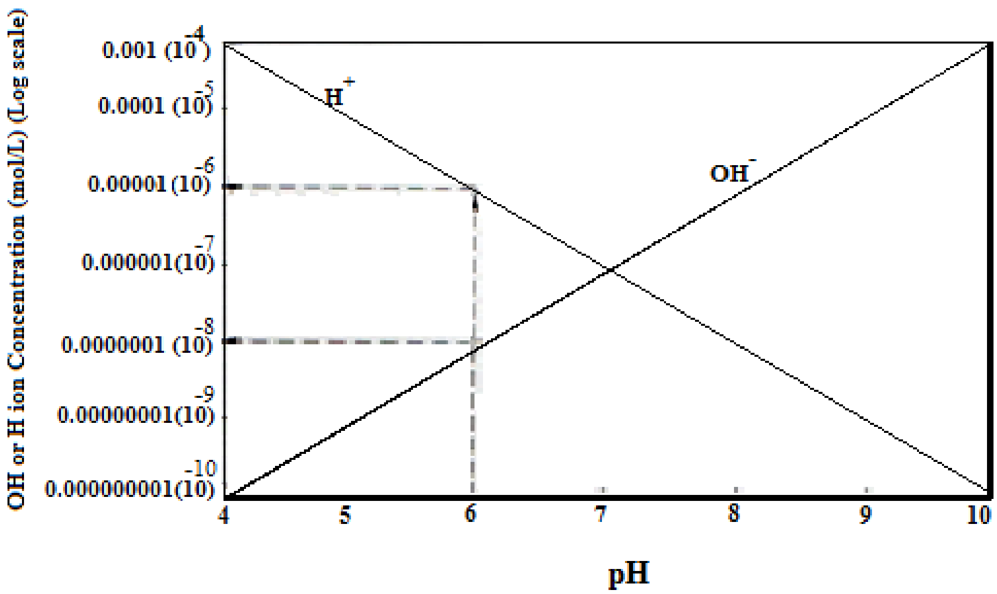

Figure 6: the relationship between pH and pOH and the concentration of hydrogen ions and hydroxyl in the soil mixture showing.

More acids forming from weathering of Ca and some silicate minerals. This is mentioned in the following equation:
Ca silicate + $2H^+ \rightarrow H_4SiO_4 + Ca^{2+}$
Some non- silicate cations like Ca^{2+}, Mg^{2+}, K^+ and Na^+ get separated from soil colloids as exchangeable cations (Khan, 2003).

The importance of Aluminum in soil

As we know the lower pH is due to the high concentration of H^+, as well as the concentration of Al^{3+} is also responsible for the acidification of soil. As in all soil minerals having Al like Aluminum silicates and Aluminum oxides in the all composition having Al. when H^+ ions absorbed by specific surface of soil for more time it remains passive and not having any exchange reaction but the soil gets eroded. In this case Al^{3+} is released and some Al^{3+} absorbed by soil colloid (Jim, 1998). The exchangeable Al^{3+} in the soil solution can have following affect 1) the Al^{3+} ions have toxic features and thus have adverse affect on plants and animals 2) Al^{3+} ions hydrolyze H_2O molecules into the H^+ and OH- . In this case Al^{3+} joins with OH^- and H^+ in the soil solution is released causing lower pH (Girard, 2005).

Interface of Human in the acidification of soil

Human activities too interfere with the soil acidity. This can occur in three ways: 1) addition of high amount of N (Nitrogen amendments) in the soil, 2) Acid rains and 3) Acid sulfate soils between soil. In the last 100 years due to intense agricultural activities the N cycle is very high. As well as the usage of Aluminum fertilizers [(Ammonium sulfate i.e, $(SO_4)_2\ NH_4$ and urea, $CO\ (NH_2)$)] are also the main reasons for soil acidification (figure 7) (Chung *et al.*, 2007) (figure 7).

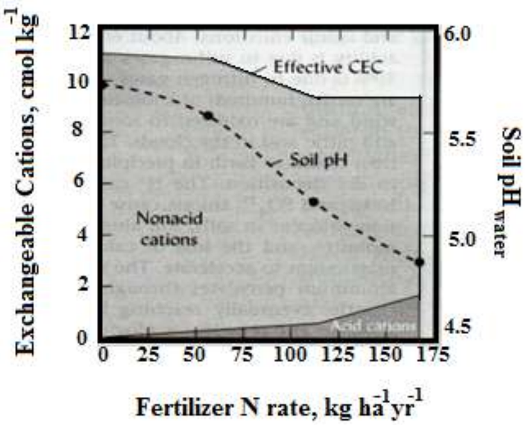

Figure 7: It's showing Aluminum fertilizer, in this case the pH of soil is gone to very down. Also when NH^{4+} and NO^{3-} given the H^+ very more produced, for acidification of soil especially NO^3- the H+ ions very more produced and its absorbed by plants roots and at the result plants acidity (Redrawn from data in Barak *et al.,* 1997).

Generally this increasing of N from is due to more usage of fertilizers. When the amount of N increasing in the soil, the soil very soon become acidic. Also when the ions of N increases in the soil more cations are absorbed by plants.

The effect of acidification on aquatic environments

Acidic soil may reaches various water sources like, river, pond, aquifers. Acid thus flown alongwith toxic elements like Aluminium, ammonium interfers with the respiration of living organism present in the water. pH below 6 is dangerous for aquatic animals interfering with the blood flow (Chen Wong, *et al.*, 1997).

The effects of acidification on plants

Higher concentration of aluminium work as growth and yield limiting factor for crops in acidic soils (when pH is ≤5.5) and the most effected part is roots. Though higher parts like stem, leaves and fruits do get effected. In addition, Al-toxicity stimulates reactive oxygen species causing oxidative stress that can damage the roots and chloroplasts, decreasing normal functioning of photo synthetic parameters. As a result of the detrimental effects of high Al, root metabolic processes, such as water and nutrient absorption, are disturbed with simultaneously decreasing calcium (Ca) uptake. Ca plays a basic role in the amelioration of pH and Al-toxicity through Al-Ca interactions improving physiological and biochemical processes in plants. Thus limestone or gypsum is used in fields (Gergichevich *et al.,* 2010).

CONCLUSION

As all know soil is one of the very important natural resources of nature and it's very important for the survival of animals and plants lives. Since it is directly related with human life and existence therefore we must protect it from different kinds of pollutions. These toxic acid when enters the soil affect other components of the soil including mineral absorption, plant growth and ultimately human health. In Afghanistan soil toxicity is a serious issue, therefore immediate measures are required to curb down this kind of pollution.

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