Available online at
www.vitalbiotech.org/currentagriculturetrends/

ISSN (E): 2583 – 1933

Curr. Agri.Tren.:e-Newsletter, (2022) *1*(5), 5-7

Current Agriculture Trends: e-Newsletter

Article ID: 127

Ferrolysis: A Pedogenic Process in Soil under Hydromorphic Conditions

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Article History
Received: 5.05.2022
Revised: 12.05.2022
Accepted: 16.05.2022

INTRODUCTION

Short-term, long-term or permanent waterlogging of the soil (soil moisture above the field capacity) is a factor describing the development of hydromorphic soils. In such soils, pedogenesis occurs under anaerobic conditions due to the filling of the pore space of the soil matrix with free water which promotes gleying and accumulation of acid organic compounds in soils. Hydrogenous Fe-accumulations, Fe-Mn concretions and nodules are also observed due to the effect of waterlogging in the horizons of soil profile. Ferrolysis is described as a dominant process to explain clay disintegration, interlayering of clay minerals in acid, seasonally wet soils where it is considered as a characterstic profile forming process. In this process, clay lattices are destroyed in a sequence of repetitive cycles, each cycle involving a reduction and an oxidation phase. During the reduction phase, iron (III) oxides are reduced, and the ferrous iron formed displaces exchangeable cations, including aluminium, on the silicates with surface charge. During the oxidation phase, ferrous iron is oxidized to ferric hydroxide and hydrogen ions. The acidic environment is conducive to clay mineral decomposition. The hydrogen ions displace the exchangeable ferrous iron and release lattice cations from the clay minerals. In every cycle, soluble cations and part of aluminium, as soluble polymers, are leached, part of the clay mineral lattice is destroyed, and the profile texture becomes more differentiated. Another portion of aluminium forms interlayers with trapped ferrous iron in 2:1 clays, transforming them to secondary chlorites. Ferrolysis is also an important mechanism to explain strong texture contrast of duplex soils and formation of acid, wet soils in which bleaching and mottling are predominant features. The bleaching may appear as albeluvic tongues surrounded by mottles or as a strongly bleached, coarse top horizon changing more or less abruptly into a denser subsoil with a significantly larger clay content.

Mechanism of Ferrolysis Process in soil

According to the principles of ferrolysis described by the scientists ferrolysis process is the result of microbial decomposition of organic matter in soils. In well aerated soils O_2 dissolved in soil water act as the main oxidant for organisms decomposing the organic remains however in the absence of sufficient O_2 during waterlogging in seasonally wet soils presence of iron oxyhydrates serves as the oxidant which become reduced to Fe^{2+} with simultaneous production of alkalinity. Fe^{2+} being soluble move through the soil to a zone containing O_2 where it is reoxidized and precipitates as $Fe(OH)_3$ producing acidity. During the reduction of $Fe(OH)_3$, OM is oxidized into H_2CO_3, organic acids and strong mineral acids. Upon reoxidation the acidity produced will turn the HCO_3 back into H_2CO_3.Iron(III) oxides in soils commonly coat other components, causing cohesion and a homogeneous brownish or reddish colour. When the iron(III) oxides are reduced and the dissolved $Fe(HCO_3)_2$ is removed from the reduced zone, the original colour is replaced by the colour of the uncoated soil particles, usually pale grey to almost white. Soils in the initial stage of ferrolysis show a seasonal variation in top soil pH with neutral pH under reducing conditions and acidic pH under oxidizing conditions in the ferrolysed horizon.

Characterstics of Ferrolysed soils

Mineralogical Characterstics

- Formation of fine quartz was detected in the fine clay fraction (0-0.2 µm) in all horizons of ferrolysed soils.
- Clay fractions of ferrolysed soil show a constant content of Fe-Mg silicates which either slightly decreases, remains constant or even increases due to the coarse particles of these minerals which disintegrate and accumulate in the clay fraction.
- Released aluminium during the ferrolysis process forms interlayers with trapped ferrous iron in 2:1 clays transforming them to secondary chlorites.
- Weathering of trioctahedral chlorite in the clay fraction in the ferrolysed soil occur by removal of interlayer OH sheets and the weathered trioctahedral chlorite with incomplete OH sheets contain $Al^{3+,}$ Fe^{2+} and Mg^{2+} in the interlayer sheets.

Chemical Characterstics

- Chemical composition of the ferrolysed soil show a decrease of Al_2O_3,Fe_2O_3,MgO,CaO,Na_2O and K_2O upwards in all soil profile and the rate of decrease is different for the different cations. Fe2+ and Mg2+ more strongly Al3+ and K+ occuply intermediate positions, Ca^{2+} and Na^{+} decreased least.
- The clay of the top horizon of ferrolysed soil contain more FeO,MgO, CaO, Na_2O, K_2O than the underlying horizon.
- Due to nutrient cycling the exchangeable Mg^{2+} and Na^{+} are absent in the top horizon where nutrient cycling is more and saturation with Al^{3+} is larger.

Physical Characterstics of Ferrolysed soil

- A textural difference between top horizons and deeper horizons in a ferrolysed soil is the result of destruction of clay minerals in the upper horizons.
- The main reason for the strong contrast in texture is considered to be clay translocation**.**

CONCLUSION

Ferrolysis is the main process for the formation of soils with horizon with strong textural contrast due to the destruction of clay minerals in the upper horizons and the clay translocation. Mineralogical , physical and

chemical characterstics of the ferrolysed soil reveal the distinct changes in the soil occurring through ferrolysis. Ferrolysis process is commonly found in water logged soils or the soil under hydromporphic conditions due to the alternate oxidizing and reducing conditions of Fe oxides prevailing in the hydromorphic soils.

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