ASPECTS REGARDING THE METHODS OF SOIL AERATION

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ABSTRACT. – Aspects regarding the methods of soil aeration. Soil aeration is a process to be carried out continuously the gas exchange between soil and atmosphere. The process is done mainly by the movement of water inside and outside him. There are three major gases in the soil (nitrogen,oxygen and carbon dioxide). Soil air composition differs from that of air by higher CO_2 content (0,3 to 0,5%). The air in the soil is very important for the dynamics of soil. Soil aeration is accomplished through mass flow and diffusion. In this paper the authors present these methods of soil aeration.

Keywords: soil aeration, diffusion, mass flow, soil gases.

1. INTRODUCTION

The air in the soil is very important for the dynamics of soil and plant growth. The air of soil contains the same gases as atmospheric air, but in different proportions (table 1) . Thus, soil air has practically the same ground of nitrogen as the atmosphere, is low in oxygen and rich in carbon dioxide, water vapour and ammonia. The content of CO_2 is always higher in soil air compared to atmosphere.

In case of insufficient ventilation of the soil, aerobic soil microorganism are affected; also reduced ventilation prevents root growth in length, and soil nutrients are not available for plants, such as: nitrates suffer denitrifications process and part of gaseous nitrogen loss.

Soil aeration is achieved by two methods: mass flow and diffusion. Mass exchange taking place between the atmosphere and soil air (during the day, the soil has a higher temperature than the atmosphere and soil gases into the atmosphere quickly go through the process of evaporation) .

At night the ground is cooler than the atmosphere and absorbs gas flow from the atmosphere. Most exchanges take place in the soil gas diffusion mechanism. Each carries its own atmosphere gas partial pressure in relation to the volume of air.

Depending on the factors leading to soil aeration (porosity, water regime) can be done in ground a poor, excessive or balanced air system. Conditions of poor air meets in excessively wet soils, especially in the regular or permanent swampy. Soils with excessive aeration are sandy with unstructured content and low air humidity.

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Balanced system of air takes place in well structured soils glomerulus, where the proportion of capillary porosity and non capillary is optimal. For the settings of the air in the soil are used to determine soil porosity throughout the profile and water content at short intervals, for at least a year. Soil aeration is conditioned primarily by soil moisture regime that is common to speak of a aerohidric soil regime.

Tabel 1. ***Atmospheric air and soil composition (volume %)***

Components	Atmospheric air (%)	Soil air (%)
Oxygen	20,87	11,5-19
Nitrogen	78,31	79,0
Carbon dioxide	0,03	0,3-3
Argon	0,76	0,76
Other gases	0,03	traces
Water vapor	1-2	1,5-2

2. GAS EXCHANGE BETWEEN SOIL AND ATMOSPHERE

Gas exchange between soil and atmosphere is crucial for the quality of metabolic reactions that take place under the soil surface, especially in agricultural ecosystems, where the degree of aeration of the soil is strongly correlated with plant vegetative state, having repercussions on the quality and quantity of crops.

Due to the porous medium properties of soil gas exchange between it and the atmosphere is possible by the aeration process, through which atmospheric oxygen enters the soil and soil carbon dioxide is emitted to the atmosphere, these two flows being generated due to concentration gradients.

The magnitude of the flow of oxygen in the atmosphere is dependent on soil texture and structure and the degree of pore filling with water, it is possible to quantify the aeration process as both direct measurements and numerical modeling.

Gas molecules in soil are in continuous thermal motion according to the kinetic theory of gases, there is also collision between molecules. In soil, a concentration gradient causes net movements of molecules from high concentration to low concentration, this gives the movement of gas by diffusion. Numerically it is explained by Fick's law of diffusion.

Diffusion is the principle process that drives gas exchange between soil air and the atmosphere. Diffusion is defined as the random thermal movement of ions or molecules that tends to bring about their uniform distribution within a continuous system.

During a period of accelerated biological activity, the levels of soil CO_2 can exceed atmospheric CO_2 levels. This difference in CO_2 concentration causes the CO_2 to diffuse from the soil to the atmosphere. Similarly reduced O_2 levels in soil produce diffusion of O_2 from the atmosphere into soil. The rate of diffusion is

greatest when a large concentration differential (gradient) exists and conductance capacity (permeability) is high.

Measurements of the rate of gaseous transport in soil are of two types: diffusion and convection. Measurements of soil aeration based on convection of gas use simple flow parameters to accurately measure mass flow through soil directly, or to measure the total air pressure or the difference in air pressure between the atmosphere and soil. Convection of soil air arises from spatial differences in air pressures due to abrupt changes in air pressure of the atmosphere, the effects of temperature differences on gas properties, infiltration and redistribution of water in the soil profile, and microbial production of gases as CO_2, NO,N_2O and CH_4.

Diffusion is a response to the concentration gradient formed between the oxygen rich atmosphere and the oxygen poor wastewater infiltration site.

3. MASS FLOW (CONVECTION) IN SOIL

This mechanism is dependant upon overall pressure gradients and is thus affected by soil water content, wind, and changes in barometric pressure. Additional phenomena affecting the pressure of soil air are the penetrations of water during infiltration, causing displacement (and sometimes compression) of antecedent soil air, the fluctuations of a shallow water table pushing air upward or drawing air downward, and the extraction of soil water by plant roots. Short-term changes in soil air pressure can also occure during tillage or compaction by machinery.

Convection can in certain circumstances contribute significantly to soil aeration.

The convective flow of air in the soil is similar in some ways to the flow of water, and different in other ways. The similarity lies in the fact that the flow of both fluids is usually impelled by, and it is proportional to a pressure gradient.

The dissimilarity results from the relative incompressibility of water in comparison with air, which is highly compressible so that its density and viscosity are strongly dependent on pressure (as well as temperature). The gravitational potential gradient, where it exists, is directly important in causing water to flow, but is hardly involved in air flow.

Quite another difference is that water has a greater affinity with the surfaces of mineral particles and is thus drawn into narrow necks and pores, forming capillary films and wedges.

Therefore, air tends to occupy the larger pores. The two fluids-water and air-coexist in the soil by occupying different portions of the pore space having different geometric configuration. For this reason, the soil exhibits toward the two fluids different conductivity or permeability functions, as these relate to the different effective diameters, tortuosity, and interconnections of the pore sets occupied by each fluid.

Only when the soil is completely permeated by one or the other, water or air, should either fluid encounter the same transmission coefficient of the medium as the other. Quite a different mechanism of convective movements of gases in the soil is the transfer of dissolved gases by rain or irrigation water infiltrating into and percolating through soils.

4. AERATION METHODS FOR BIODEGRADABLE SOILS

Psysical and biological processes have a major influence on the process of soil aeration due to: transport of oxygen, humidity and heat of air flow and diffusion, oxygen consumption and water by microorganisms and heat generated by bioreaction. The factors that are affecting soil aeration are draining excess water, the coefficient of soil respiration, soil profile, soil pH.

Efficiency of biodegradation based on the degree of soil respiration can be calculated as the product of CO_2 accumulated over a period of time (Ururahy Adriana, 1998). Biodegradation efficiency can be assessed by reducing the concentration of hydrocarbons.Intensification of soil aeration leads to improvement of biodegradation efficiency of hydrocarbons, because it emphasizes soil microbial activity resulting in increased oil consumption by the microorganism (Monica Alina Nedelcu, 2010).

(1) $EB\ (\%) = CO_{2bio} \times 100/C_i$

(2) $CO_{2\ bio} = 2 \times CO_{2\ total} - CO_{2\ control}$

Where: EB-biodegradation efficienty (% μmoles/μmoles) ;
CO_{2bio} -1CO_2 produced by microbial activity (μmoles) ;
CO_{2total} –CO_2 total accumulated (μmoles) ;
C_i - initial carbon equivalent (μmoles) ;
$CO_{2\ control}$ -gained control of CO_2 (μmoles).

A soil aeration method is " biopile " method (this method of aeration of the soil has been studied and researched in "Studies on polluted soil aeration systems to improve efficiency in the treatment of soil remediation using the "biopile" method by Monica Alina Nedelcu, V. Micle, Monica Ioana Berar, 2010).

Method "BIOPILE" consists on excavating soil and the formation of piles of contaminated soil in order to improve conditions for biodegradation.

For the aeration of the pile of contaminated soil is provided a system of perforated pipes installed at the base of the heap in a permeable gravel layer that allows regular and uniform air distribution throughout the whole heap. The proper growth conditions in the method "biopile" ,the speed and the degree of degradation may increase (Monica Alina Nedelcu, 2010).

Extracted air can be treated to remove volatile compounds using a system such as activated carbon filtration (Micle V., 2009).

Operation Method "biopile" is due to physical and biological processes. Source of oxygen increases with increasing air filter, heat and water loss are intensified.

Therefore stimulate the flow of air does not lead to an improvement in terms of biodegradation in the ambient temperature is lower than that needed for optimum biodegradation in soil pile. In order to optimize rehabilitation system must understand how increasing the flow of air will change the internal temperature and moisture content of the soil pile. In turn, the moisture content and temperature are also affected by microbial activity.

In general, are used two aeration systems : aeration system with horizontal pipes and aeration system with vertical pipes.

Horizontal tube aeration system usually includes fans who will be attached to the aeration pipe system except when soil aeration is done manually (Rusu T., 2007). Most ventilation systems are based on horizontal perforated pipes placed at random.

Vertical tube aeration system consists of perforated pipes placed vertically with wind turbines and it has been compared with a standard structure with two piles of perforated pipes placed horizontally (Micle V., 2009).

Both piles were composed of a similar mix of soil contaminated with diesel fuel, wood chips, compost, nitrogen, phosphorus, and potassium. Hydrocarbons were recovered using solvent extraction, and is determined both gravimetrically and by gas chromatography.

Each soil pile was built using 3 m^3 of soil contaminated with diesel, 1.26 m^3 of soil in which: chips 0.21 m^3 and compost 1.05 m^3. Soil hydrocarbon concentrations were between 18,000 and 25,000 ppm. Contaminated soil was stacked in piles about a 1 m height, 2 m wide and 3 m in length.

The results are reducing the hydrocarbon content of both piles and are presented in tables 2 and table 3.

Table 2. ***Variations in time of diesel content in the piles***

Pile with standard aeration		
Day	Diesel mg/kg	Percentage (%)
0	20,318	17
3	20,153	2
6	15,261	13
15	15,800	27
23	16,517	12
30	15,497	21

Table 3. ***Variations in time of diesel content in the piles***

Pile with new system of aeration		
Day	Diesel mg/kg	Percentage(%)
0	20,318	17
3	20,153	2
6	15,261	13
15	15,800	27
23	16,517	12
30	15,497	21

The results confirmed that the excessive loss of water is due to intensification of aeration inducing a negative impact on the process of biodegradation. (Monica Alina Nedelcu, 2010)

CONCLUSION

Worldwide the most common method of soil aeration is the horizontal tube method. After elaborating the study it shows that method biopile is an effective method for maintaining an optimum balance in case of soil aeration, providing ventilation system using a uniform vertical flow aeration.

To control the flow of air that affects the water content is necessary for continuously monitoring the soil moisture.

This study was to compare systems in soils contaminated with hydrocarbons to highlight the efficiency of biodegradation of organic pollutants.

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