Agricultural practices for soil carbon sequestration

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People have been utilizing soil organic carbon since ancient time and they have been trying to restore it ever since. Egypt, one of the most prosperous ancient civilizations, subsisted a long time, as a result utilization of Nile's (alluvium) deposits. They found, that fertilization with farmyard manure increase yield production.

New and improved techniques and technologies are applied in the contemporary agriculture for soil carbon sequestration. They could be grouped as following categories:

1.Natural

- Fertilization with farmyard manure;
- Fertilization with composted plant and other organic wastes;
- Green manure;
- Growing of perennial grass;
- Cutting of straw, stamps of maize, sunflower or tobacco and incorporation into soil.

2.Utilization of natural and synthetic soil amendments.

- Liming of acid soils;
- Balanced fertilization with nitrogen and other mineral fertilizers;
- Melioration with natural adsorbents – zeolites, vermiculites, phosphorites, clay minerals, peat, coal, extracted humic acids.
- Application of modified water soluble polymers (structure generate)

3. High technologies:

- Inoculation of seeds in seedling with Rhizosphere microflora;
- Treating of plant with growth stimulators for increasing of biomass yield;
- Under layer seedling with cereals (close growing crops)
- Regulation of oxy-reduction processes in soils and composting of organic materials;
- Periodically biodegradation of organic pollutants.

4. Hydromeliorative practices and soil erosion control:

- Drainage of waterlogged soils;
- Utilization of modern rain fall irrigation system with suitable drops size distribution to prevent soil aggregates disintegration;
- Utilization of drop irrigation system;
- Soil erosion control and soil conservation tillage.

5.Remediation activities:

- Biological reclamation of disturbed lands with application of the amendments mentioned above and combination with organic fertilization and perennial grassing or forestation.

It is well known that seasonal degradation of ozone layer during spring and autumn is mainly due to the biological processes and 40% are goes to the active agriculture. As a result of this soil, organic fertilizers, sewage sludge from waste water treatment plants and other dumps for organic wastes release CH_4, N_2O, SH_2, CO_2 etc. Seasonal character is typical for these emissions connected with periods with active microbial activity in anaerobic conditions and corresponding reduction conditions of the media. Similar emissions are typical for the rice plots where the processes of destruction continued after the end of the spring.

If we accept that humus formation is one of the natural synthetic processes connected with high oxy-reduction potential of the media, than the destruction of the organic material is related to increasing of reduction parameters of the media, respectively oxy-reduction potential. Oxy-reduction potential is controlled more complicated in the case of polluted and water logged soils, where the natural enzyme activity is disturbed. Two different phenomena are observed responsible for non synthetic transformation of organic material – biological – I phase and physicochemical II phase. The first phase is connected with destruction of organic material in anaerobic conditions – compacted and waterlogged soils, and after that both, soil buffer capability and present of ions couples with oxy-reduction properties take place–Fe^{2+}-Fe^{3+}, Mn^{2+}-Mn^{4+}, Cu^{2+} Cu+, SO_4^{2-}-SH etc. (Chakalov et al., 2002; Ganev,1990; Gateva, 1986; Popova et al., 2002).

To limit the activities of obligate and facultative anaerobes in agricultural practices the following measures are used – appropriate soil tillage in favourable agro technical term (prescription), fertilization with composted farmyard manure or lumber compost, incorporation of dried organic wastes and by no means green fertilization with fresh plant residues. To limit the impact of the second phase application of mineral or organic adsorbents– zeolites, monthmorilonites, amphoteric phosphorites, vermiculites, humic acids is recommended (Gulko, Haziev, 1990; Grishina, 1986; Orlov 1993; Allen and Ming, 1995; Benkova et al., 2005 Burdick, 1965; Chakalov, et al, 2002; Eberl et al 1995).

Balanced mineral plant nutrition is very important factor influenced on the soil organic carbon sequestration. Excess of nitrogen fertilizers could be led to both, destruction of organic substances and contamination of atmosphere with nitrogen oxides. Surplus of phosphorous may slow down plant nutrition with microelements, especially - Zn. The last one is an additional factor which limited good plant growing and respectively quantity of plant residues.

Common practice in the animal farm is to collect farmyard manure in a dunghill, where it decays in the natural conditions. That way the surface layer only is under aerobic conditions, where the lowest layers – anaerobic ones. This leads to lost of most than half part of nitrogen, part of the sulfur containing amino acids transformed to SH_2.Organic substances destroyed with minimum 30% lost of organic carbon.

Good agricultural practice for maintaining and increasing organic carbon in farmyard manure is formation of aerobic conditions with application of accelerators of composting processes (Comost Vivo – immobilized cells of *Aspergilus niger* on the natural bentonite; TRICHODEX – immobilized culture of *Trichoderma harsianum*; АГАТ-immobilized culture of *Pseudomonas aureofaciens*.; BIOL.I.F.E.™ and „Baikal" - immobilized culture of bacteria from genus *Pseudomonas, Bacillus* etc.), as well as oxidizers of realizing SH_2 – bacteria, genus *Thiobacillus*, and many others substances.

Effective micro-organisms (EM) consist of common and food-grade aerobic and anaerobic micro-organisms: photosynthetic bacteria, lactobacillus, streptomyces, actinomycetes, yeast, etc. The strains of the micro-organisms are commonly available from microbe banks or from the environment. There are no genetically engineered strains that are in use. Since 1999, seven small-scale organic fertilizer units have been using the EM-based quick production process in Myanmar (FAO, 2002). They are owned and operated by women's income generation groups. A unit consists of nine pits measuring about 180 cm (length) × 120 cm (width) × 90 cm (depth), enclosed by low walls and covered with a roof . The IBS rapid composting technology (Virginia, 1997) involves inoculating the plant substrates used for composting with cultures of *Trichoderma harzianum*, a cellulose decomposer fungus. The fungus, grown in a medium of sawdust mixed with the leaves of a leguminous tree called ipil ipil (*Leucaena leucocephala*), is termed compost fungus activator (CFA). The technology is a development of the wind-row type of composting. Using this procedure, the composting time ranges from 21 to 45 days depending on the plant substrates used.[TAKAHIRO KANAGAWA AND EIICHI MIKAMI (1989); Steven McKinsey Zicari (2003) Adoki A. (2007)].

Method of lumbri composting is popular now and it presents transformation of organic wastes with red Californian worm (*Lumbricus*). The end product contains humus–like substances and carbon lost is small.

Another method for aerobic composting propose periodically aeration of organic manure and additionally application of lignin-cellulose wastes, which balanced the ratio C:N. Traditionally the wastes are straw, maize residues, rice hulls, barks, crushed trees branches etc. Market offers microbiological products that accelerate degradation of lignin-cellulose wastes, which accelerate composting processes. End products are characterized with good agricultural value and they are free of phyto pathogens and pathogens for warm-blooded.

Outside breeding of birds – hens, broilers, turkey, the litter usual consist straw or barks. Good agricultural practice requires application of 1% of the weight of litter to limit realizing of NH_3. That way nitrogen is stored in the litter and lignin-cellulose destruction is better. This practice could be applied in cattle-shed, shepherd's and other places for inside breeding of live stocks.(LINGSHUANG CAI et al, 2007;US Patent 028168, 2007); Eng et al., 2003; Ziggers, 2003; Irwin, 1996; Bernal, et al., 1993).

Conclusion

Maintaining and increasing soil organic carbon trough modern agricultural practices is a combination of technological activities of soil tillage, hydromeliorative practices, balanced fertilization with mineral, organic and microbial fertilizers, economically utilization of pesticides and returning of plant residues to soil, mechanically treated or preliminary composted.

References

Allen, E., and D. Ming 1995, Recent progress in the use of the natural zeolite in agronomy and horticulture. In: Natural Zeolites'93, Ming D, and F. Mumpton eds, ICNZ, Brockport, New York, USA 447-490.

Aluminum silicates reduce manure odor and cut greenhouse gas emissions. Research by Olds College Composting Technology Centre. www.cattle.ca.com, www.ag-waste.com, 2005,March/April, Article Archives

Adoki A. (2007) Influence of divalent metal ions on degradation of dimethylsulphide by intact cells of Thiobacillus thioparus TK-m African Journal of Biotechnology, Vol. 6, No. 11, 4 June 2007, pp. 1343-1347.

Bernal, M.P., Lopez-Real, J.M., and Scott, K.M., 1993, Applcation of natural zeolites for the reduction of ammonia emissions during the composting of organic wastes in a laboratory composting simulator. Bioresource Technology, vol. 43, p 35-39.

Benkova, M., Filcheva, E. and Raychev, T. Peat effect as component of organo-mineral ameliorates on humus state at acidic heavy metal polluted soil. In proceeding National Conf. With Int. Partcipation : MANAGEMENT, USE AND PROTECTION OF SOIL RESOURCES, 15-19 May, Sofia, Bulgaria, 2005, pp. 432-436.

Burdick, E.M. 1965. Commercial Humates for Agriculture and the Fertilizer Industry. Economic Botany, Vol. 19, No. 2:152-156.

Chakalov, K., T. Popova, and E. Filcheva. 2002. Soil fertility management with zeolite amendments. II. Zeolite effect on the maintaining the soil Eh. In: Int. Sym. “Agricultural Practices and Policies for Carbon Sequestration in Soils”. CRC- Press. LLC. Boston, USA 229-235.

Chakalov K., T. Popova, E. Filcheva, K. Mitov. 2002. Improvement of the efficiency of zeolite treatment of polluted soils for their better storage of carbon and nitrogen Final research report – re – entrustment contract between RITE, Kyoto, Japan, Japans government represent by NEDO and NIPRORUDA JSCo, Sofia, Bulgaria, March 2002, 20 pp.

Eberl D., K. Barbarick, and T. Lai 1995, Influence of NH_4 -exchanged clinoptilolite on nutrient concentration in Sorghum Sudan grass. In: Natural Zeolites’93, Ming D., and F. Mumpton eds, ICNZ, Brockport, New York, USA 491-504.

Eng,K.S.,Hutcheson, D.P. and Bechtel R., 2003, Adding Potassium, clinoptilolite zeolite and yucca extract feedlot diets to reduce nitrogen losses from manure., J. Animal ci., vol. 81.

Filcheva, E. and Chakalov, K. Soil fertility management with zeolite amendments. I. Effect of zeolite on carbon sequestration. A review In: Int. Sym. “Agricult. Practices and Policies for Carbon Sequestration in Soils”. CRC- Press. LLC, Boston, USA, 2002, pp. 223-228.

Filcheva, E., Popova, T., Chakalov, K. and Mitov, K. Improvement of zeolite effect on the polluted soils for nitrogen and carbon storage. III. Influence of zeolite amendments on organic carbon storage in heavy metal polluted soils. In Proc.: 6th International Conference on the Occurrence, Properties and Utilization of Natural Zeolites, Thessaloniki, GREECE, June 3-7, 2002

Ganev, S. (1990). Modern soil chemistry. Nauka i Iskustvo Sofia., 1990, 371 pp

Gateva, A. (1986). Ion-hydroxide equilibrium of amphoteric elements. Soil sci. and agro chemistry. No 1

Ghosh, S.K., and Guhasarkar, C.K. (2001) Bio-remediation to clean up environment. www.thehindubusinessline.com/2001/04/05/stories/040525hg.htm

Gulko, A.E, Haziev, F.N. 1990. Some properties of humus-peroxides complex. Soil Science, 2, 30-36. (Ru)

Grishina, L.A. 1986. Humus formation and humus state of soils.. MSU, M., pp. 244.

Natural Environmental Systems, LLC. http://www.naturalenviro.com;

Irwin, Robert, 1996, Clay (Zeolite) additive keeps ammonia at bay. www.agpub.on.ca also www.ae.iastate.edu/agwastes

LINGSHUANG CAI ; KOZIEL Jacek A. ; YI LIANG ; ANH THU NGUYEN ; HONGWEI XIN ; (2007) Evaluation of zeolite for control of odorants emissions from simulated poultry manure storage , Journal of environmental quality ISSN 0047-2425 American Society of Agronomy, Madison, WI, ETATS-UNIS (1972) (Revue) 2007, vol. 36, n°1, pp. 184-193.

North America’s Zeolite BRZ ZEOLITE http://www.zeolite.ca/Composting.htm

Orlov, D.S. 1993. Properties and function of humic acids. Humic substances in biosphere. M., 16-27.

Popova, T., Chakalov, K., Filcheva, E. and Mitov, K. Improvement of zeolite effect on the polluted soils for nitrogen and carbon storage. II. Influence of zeolite amendment on nitrogen storage in heavy metal and As polluted soils. In Proc.: 6th International Conference on the Occurrence, Properties and Utilization of Natural Zeolites, Thessaloniki, GREECE, June 3-7, 2002.

Steven McKinsey Zicari (2003) REMOVAL OF HYDROGEN SULFIDE FROM BIOGAS USING COW-MANURE COMPOST; A Thesis, Presented to the Faculty of the Graduate School of Cornell University in Partial Fulfillment of the Requirements for the Degree of Master of Science by January 2003.

TAKAHIRO KANAGAWA AND EIICHI MIKAMI (1989) Removal of Methanethiol, Dimethyl Sulfide, Dimethyl Disulfide, and Hydrogen Sulfide from Contaminated Air by Thiobacillus thioparus TK-m APPLIED AND ENVIRONMENTAL MICROBIOLOGY. Vol. 55, No. 3 p. 555-558.

United States Patent 2007 02 8168 Kind Code:A1 ANIMAL FEED AND METHODS FOR REDUCING AMMONIA AND PHOSPHORUS LEVELS IN MANURE.

WO/2007/068248) PROCEDE ET INSTALLATION DE PRODUCTION D’UN ENGRAIS NATURELMethod according to claim 1 wherein a batch of Thiobacillus thiooxidans bacteria is added to the mixture and/or other related bacteria such as Thiobacillus ferroooxidans.

Ziggers, D., 2003, Binding ammonia with volcanic powder, Feed Tech, July 1, 2003, p. 18-19