THE CLIMATIC CONDITIONS INFLUENCE ON THE MILLET YIELDS IN THE ENHANCING NATURAL ATTENUATION PROCESS OF THE CRUDE OIL THROUGH FERTILISATION

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Abstract

The concept of the natural attenuation of the soil pollutants, more frequently used in the recent decades, has a larger meaning than the natural biodegradation, including also the natural physical-chemical processes that determine the reduction, immobilization or destruction of the contaminants in the environment through advection, diffusion, volatilization, sorbtion/desorbtion, ion exchanges, abiotic complexation, etc.

The enhancing natural attenuation through phytoremediation of the organic contaminants can be performed through the technologies of applied culture that include measures of deep loosening for soil aeration, amendments for the acidity correction, organic and mineral fertilizers that stimulate the activity of the specialized microorganisms in the biodegradation of the contaminants.

The experiment of the Research and Development Station Oradea, done in the period 1993-2002 followed the amelioration of the soils polluted with crude oil brought from Suplacu de Barcau through the phytoremediation with millet cultivated on controlled polluted parcels with the concentration of 3% on ploughed layer. There were applied different doses of manure (0, 50, 100 and 150 t/ha) and different doses of complex mineral fertilizers ($N_0P_0K_0$, $N_{100}P_{80}K_{70}$, $N_{200}P_{160}K_{140}$ and $N_{300}P_{240}K_{210}$).

The results of the researches in the first three years highlight the importance of the climatic conditions during the vegetation period for the maximization of the effects of the enhancing natural attenuation of the soil pollutants.

The correlative links established between the climatic indices, the manure quantities and the doses of administrated complex fertilizers and respectively the millet-hay production present that the maximum of the biodegradation of the crude oil in soil is obtained for the maximal values of the Martonne aridity index (the maximum of the precipitations sum and the minimum of the average temperatures during the vegetation period) and respectively the maximum of the administrated organic fertilizers (150 t/ha manure) and mineral fertilizers ($N_{300}P_{240}K_{210}$).

Key words: enhancing natural attenuation, biodegradation, phytoremediation, crude oil, climatic indices, fertilization system;

INTRODUCTION

The land area polluted with crude oil and salt waters in Romania is over 50000 ha being present especially in the field of the crude oil extraction. (Voiculescu Anca Rovena et al, 2006)

In Bihor County the land areas affected by the historical pollution with crude oil are located in the activity zones of the former crude oil fields

of Suplacu de Barcau, Marghita and Oradea, now undertaken by OMV, these being evaluated at more than 250 ha. (Sabău N.C., et al, 2002)

The researches done here (Colibaş I., et al, 1995; Toti Mh., et al, 2003; Cocuț Dana-Camelia, et al., 2008) and worldwide (Alexander, M., 1994; Wiedermeier T.H., et al. 1999; Vidali M., 2001; Li H., et al., 2006) presented the fact that the soil has the degradation capacity of the organic pollutants and implicitly of petroleum products.

The process through that the living organisms, microorganisms and vegetables are used for the degradation of the soil contaminants or for the reduction of their toxicity, is named bioremediation. (Vidali M., 2001)

The bioremediation of the polluted soils with organic contaminants that are produced intrinsic, under natural conditions, without the applying of some engineering technologies, is named natural bioremediation. (Wiedermeier, T. H., et al., 1995)

The bioremediation technology of the contaminated soils "in situ" uses beside the specialized microorganisms in the degradation of the organic contaminants also vegetables (Phytoremediation) that action through many mechanisms: phytoextraction, phytostabilization, rhizofiltration, phytodegradation and phytovolatilization. (Lan J.K.,, 2004; Ayotamuno J.M., et al., 2006; Robinson B. et Anderson C., 2007; Dzhura N., et al., 2008; Gerhardt K.E., et al., 2009)

In the last decades the concept of natural biodegradation of the pollutants is much more replaced by the concept of natural attenuation that nevertheless has a larger meaning, the reduction of the contaminants concentration being realized also through the physical-chemical processes (advection, dispersion, dilution, diffusion, volatilization, sorbtion/desorbtion, ion exchanges, abiotic complexing, etc) that can immobilize or destroy the contaminants. (Wiedermeier T.H., et al. 1999)

Regarding the natural attenuation of the soil pollutants it was defined the concept of enhancement of the natural attenuation (Enhanced Natural Attenuation - ENA) that refers to the measures taken for the initiation or intensification of the process of natural attenuation with the aim of the faster decrease of the contaminants in the environment.

Siciliano S.D., et al., 2003 shows that concerning the phyroremediation of the soils polluted with polyaromatic hydrocarbons, in the first period after the pollution it is affected negatively the microbial composition and thus it is altered the biodegradability function of the soil. After the adaptation to the new toxicity conditions, the microbial composition of the soil is recovered, developing especially the specialized genotypes in the biodegradation of the soil pollutants.

With the aim of the enhancement of the natural attenuation through phytoremediation and of initiation of the biodegradation process, there are

often used specialized bacteria, selected from the contaminated zones, together with vegetables, the technology being known under the name of bioaugumentation. (Purohit H., 2006, Glick B.R., 2010).

The intensification of the phytoremediation processes of the contaminants can be performed through the technologies of applied culture that include mesures of deep loosening for soil aeration, amendments for the acidity correction, organic and mineral fertilizers that stimulate the activity of the specialized microorganisms in the biodegradation of the pollutant. (Olson P.E., et al., 2008)

The results of the researches done in Oradea in the period 1993 - 2002 regarding the controlled soil pollution with crude oil presented that through the cultivation of the polluted parcels (1, 3, 5 and 10 % crude oil on ploughed layer), with millet and spring wheat it is produced the biodegradation of the crude oil. The time intervals necessary for the biodegradation are dependent on the climatic conditions during the vegetation period of the cultures and they are between 7 - 8 years for small concentrations and more than 10 years for the maximal researched concentration (Şandor Maria and Sabău N.C., 2007, Şandor Maria et al., 2007, Sabău N.C., et al., 2009, Sabău N.C., et al., 2010).

MATERIAL AND METHOD

The experimental field regarding the melioration of polluted with crude oil soil is carried out at Agricultural Research and Development Station Oradea on a haplic luvosoil.

The experimental device was carried out in 1993, at the same time with the experiment looking the study of different doses of crude oil from Suplacu de Barcău effect on yields, being cultivated in the first three years with millet and then in the next seven years with spring wheat, Speranța breed.

The experiment looking "The agrochemical melioration of polluted by crude oil of soils" is an experiment having three factors, the type 2 x 4 x 4, with microparcels of 1 m^2, set out randomized, in four repetitions after the system of subdivided parcels.

The studied factors are:

The factor A: Pollution by crude oil: a_1 – control unpolluted; a_2 - polluted by crude oil, in concentration of 3 % (9 l/m^2) on ploughed layer;

The factor B: Organic fertilizer: b_0 - 0 t/ha manure; b_1 – 50 t/ha manure; b_2 – 100 t/ha manure; b_3 – 150 t/ha manure;

The factor C: Mineral fertilizer: c_0 – $N_0P_0K_0$ kg/ha; c_1 - $N_{100}P_{80}K_{70}$ kg/ha; c_2 – $N_{200}P_{160}K_{140}$ kg/ha; c_3 – $N_{300}P_{240}K_{210}$ kg/ha;

The objective of this paper is to study the influence of climatic conditions from the first three years of experiment, when he is cultivated by

millet about Enhanced Natural Attenuation (ENA) process through fertilization.

RESULTS AND DISSCUSIONS

The climate conditions of the studied period (1993-1995) are characterized by the registrations from Oradea Weather Station, where the multiannual average of rainfall is 635,0 mm and the air temperature is 10,5 °C. (Table 1.)

Table 1.

Climate characteristics of the research period\ Oradea Weather Station (1993-1995)

Nr. crt.	Year	Rainfall		Temperatures	
		mm	Differences	˚C	Differences
1	1993	503,5	-131,5	10,7	+ 0,2
2	1994	532,0	-103,0	11,8	+ 1,3
3	1995	636,9	+1,9	10,6	+ 0,1
	Average 1993-1995	557,5	- 77,5	11,0	+ 0,5
	Multiannual Average	635,0	-	10,5	-

The annual rainfall of studied period was between 503,5 mm in 1993 and 636,9 mm in 1995, having diverted from the annual average with values between– 131,5 mm and + 1,9 mm, and the variation interval of annual temperature was between 10,6 – 11,8 ˚C, with positive differences given the average of 0,1-1,3 °C. This shows that the studied period is droughty, except the last year and warmer than the average year.

The average millet-hay yields registered on the parcels under control polluted with crude oil, 3 % concentration on ploughed layer, in the natural attenuation process, through phytoremediation are from 12,1 q/ha, in the first year to 30,7 q/ha in the last year of studied period. (Fig.1.)

The enhancing natural attenuation measures, organic fertilizer with 0, 50, 100 and 150 to/ha manure and mineral fertilizer, $N_0P_0K_0$, $N_{100}P_{80}K_{70}$, $N_{200}P_{160}K_{140}$ and $N_{300}P_{240}K_{210}$ administration, have the effect of increasing millet-hay yields on polluted parcels.

If in the case of the a singular fertilizer system the yields are between 22,4 – 47,2 q/ha, the cumulate effects of the two fertilizer systems, organic and mineral (Manure x NPK) are bigger, the yields became of 29,1-50,7 q/ha.

In order to highlight the effect of the climate conditions from the years the researches were carried out, the correlative links between millet yield and the main climate elements that contribute to crop formation (rainfall and temperature) were tested.

Both millet-hay yields (q/ha) – rainfall sum (mm) from the vegetation period (V-VIII months) correlations and millet-hay yields (q/ha) – average

temperature (°C) from the months of vegetation period correlations are second degree polynomial, and look like $Y = aX^2 + bX + c$. (Table 2.)

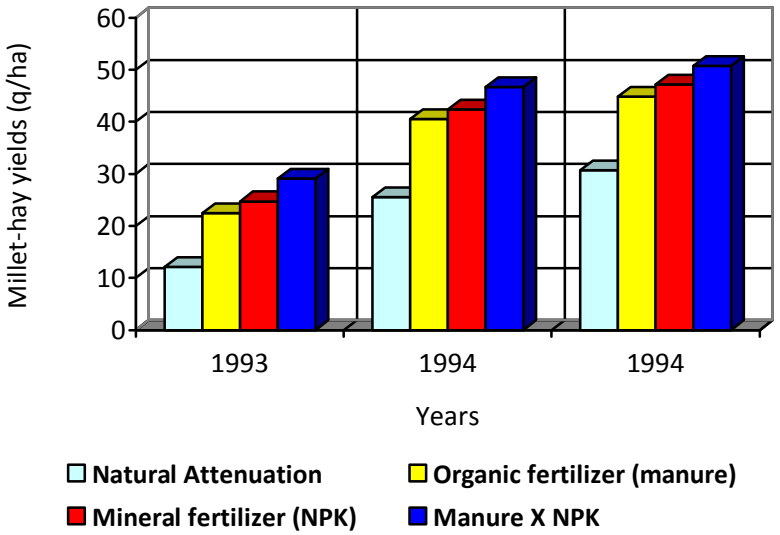

Fig.1. The average millet-hay yields (q/ha) of different variants of enhanced natural attenuation of 3 % crude oil concentration from soil

Table 2.

The influence of climate conditions, from vegetation period on millet-hay yields (1993-1995)

Current number	Variant	Rainfall sum $R_{V\text{-}VIII}$	Average temperature $T_{V\text{-}VIII}$	Correlation coefficient/ Signification
1.	Natural attenuation	$Y = -0.0094R^2 + 4.7647R - 555.14$	$Y = -11.233T^2 + 388.61T - 3310.1$	0.871**
2.	Organic fertilizer (manure)	$Y = -0.0079R^2 + 4.0582R - 474.48$	$Y = -9.1176T^2 + 313.28T - 2643.9$	0.853***
3.	Mineral fertilizer (NPK)	$Y = -0.0078R^2 + 4.0168R - 469.9$	$Y = -9.1513T^2 + 315.07T - 2667$	0.937***
4.	Cumulative effect (manure x NPK)	$Y = -0.0037R^2 + 1.9937R - 237.7$	$Y = -3.5126T^2 + 115.86T - 922.99$	0.893***

The correlative links thus established are very significant for all the enhanced natural attenuation variants and only distinct significant in the case of natural attenuation variant.

In order to study the links between the millet-hay yields from the natural attenuation and enhanced natural attenuation variants, on 3 % crude oil concentration parcels and climate conditions the de Martone Aridity index was used. (Fig. 2.)

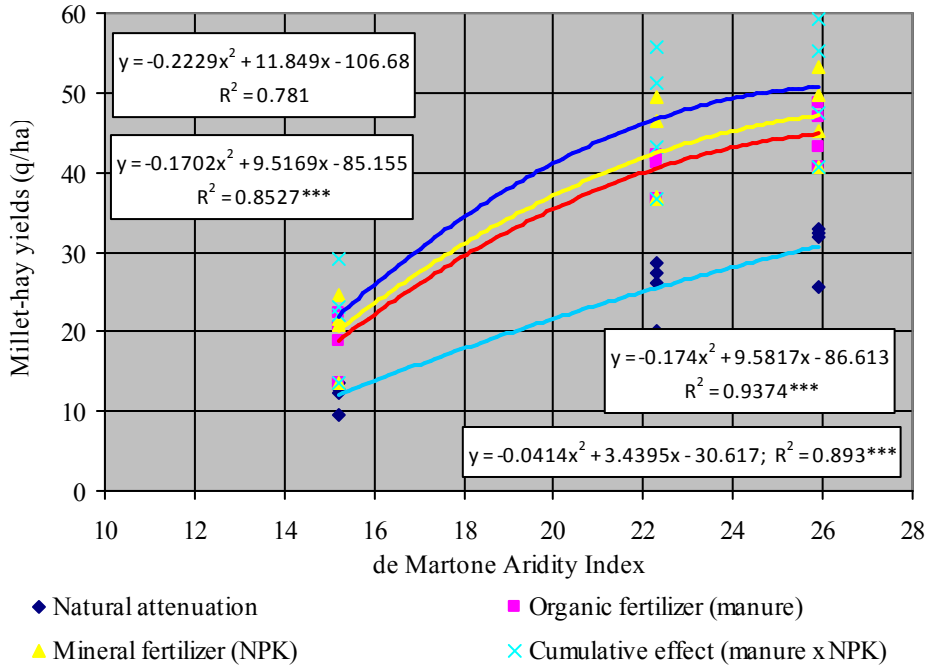

Fig.2. Correlations between millet-hay yields and de Martone Aridity Index, during the vegetation period

The shape of polynomial second degree correlations, very significant in the case of all variants show that the yields increase with the growth of de Martone Aridity Index values.

Seeing that the yields of natural and enhancing natural attenuation variants are in direct correlation with the values of de Martone Aridity Index, we tried to emphasize the cumulative influence of this and the quantity (doses) of the fertilizers.

The second degree polynomial correlations with two factors: X_1 – de Martone Aridity Index; X_2 – the quantities/doses of fertilizer and the dependence between the two factors, very significant statistical was established. (Table 3.)

The highest correlation coefficient is for the link between de Martone index and the organic fertilizer with manure and respective the yields (R^2=0,9978) but the coefficient of dependence between climate index and the manure quantity administered is negative.

The cumulate effects of the two factor studied, de Martone aridity index and the dosses of complex fertilizer administered and respective the commune effect of manure quantity and complex fertilizer doses, on millet hay yields, expressed through X_1X_2 coefficients are positive.

Table 3.

The influence of enhanced natural attenuation measures and climate conditions on millet-hay yields on a polluted soil with 3 % crude oil concentration

Current number	Enhanced natural attenuation variant	X_1	X_2	Correlative equation	Correlation coefficient
1.	Organic fertilizer	de Martone Index	Manure (x100 to/ha)	$Y=-93,768+9,8030X_1-0,1782X_1^2+10,2917X_2-2,9X_2^2-0,0493X_1X_2;$	0,9978***
2.	Mineral fertilizer	de Martone Index	Complex ($xN_{100}P_{80}K_{70}$)	$Y=-90,6961+9,5668X_1-0,1744X_1^2+2,8564X_2-0,2167X_2^2+0,0922X_1X_2;$	0,9935***
3.	Organic and mineral fertilizer	De Martone Index	Manure and complex fertilizer	$Y=-113,361+11,886X_1-0,2277X_1^2+6,1074X_2-1,0255X_2^2+0,1002X_1X_2;$	0,9932***

The most influence of the two factors studied, on yields result in the case of cumulative measures, manure plus complex fertilizer and climate de Martone index. (Fig.3.)

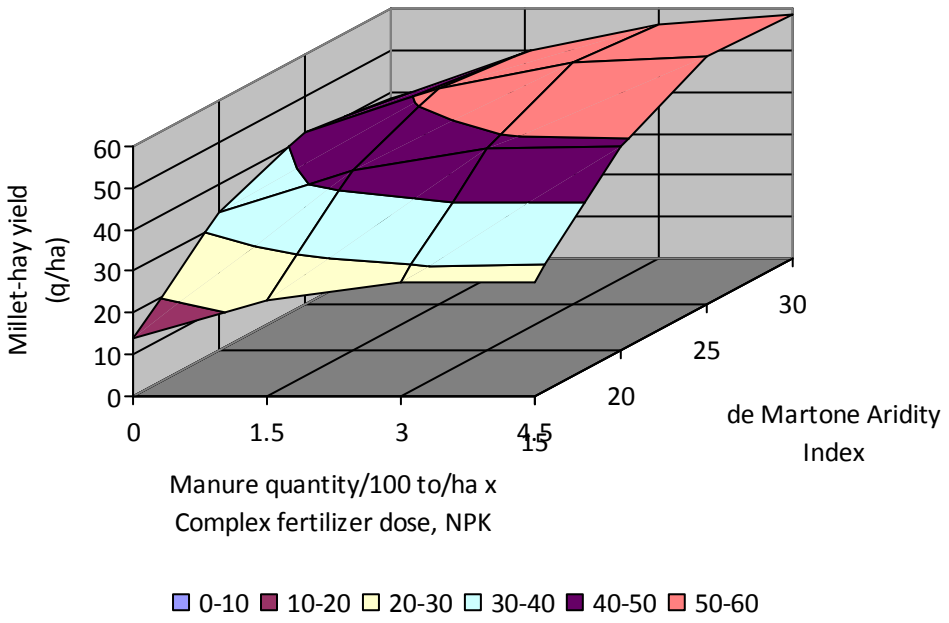

Fig.3. The cumulative influence of de Martone Index, manure quantity and complex fertilizer doses on millet-hay yields

If we consider that the yields indicate the intensity of enhanced natural attenuation through phytoremediation with millet of contaminant

from soil (3% crude oil concentration), it can conclude that the maximum biodegradation are obtained for maximum values of de Martone Aridity index (the maximum of rainfall sum and minimum of average temperature) from vegetation period and maximum of fertilizers administrated (150 t/ha manure and three doses of complex fertilizer $N_{300}P_{240}K_{210}$).

CONCLUSIONS

The enhancing natural attenuation measures, organic fertilizer with 0, 50, 100 and 150 to/ha manure and mineral fertilizer, $N_0P_0K_0$, $N_{100}P_{80}K_{70}$, $N_{200}P_{160}K_{140}$ and $N_{300}P_{240}K_{210}$ administration, have the effect of increasing millet-hay yields on polluted parcels.

Both millet-hay yields (q/ha) – rainfall sum (mm) from the vegetation period (V-VIII months) correlations and millet-hay yields (q/ha) – average temperature (°C) from the months of vegetation period, the correlations are second degree polynomial, very and distinct significant for all the enhancing natural attenuation variants are established.

The influence of climate conditions (X_1 – de Martone Aridity Index) and fertilizer systems (X_2 – the quantities/doses of fertilizer) on millet-hay yields, in the enhancing natural attenuation process of crude oil from soil is described by the second degree polynomial correlations with two factors and the dependence between the two factors, very significant statistical.

The maximum biodegradation are obtained for maximum values of de Martone Aridity index (the maximum of rainfall sum and minimum of average temperature) from vegetation period and maximum of fertilizers administrated (150 t/ha manure and three doses of complex fertilizer $N_{300}P_{240}K_{210}$).

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