ECOLOGICAL LOADS AND CRITERION FOR SOIL CONTAMINATION

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When processing hazard analyses of locations polluted with anthropogenic activities in agreement with regulations, the content of selected contaminants in soil dry matter is analysed. This criterion parameter, however, does not express the actual hazardous character of substances that is given by ecotoxicity of migration forms of these substances, their mobility conditioned by concrete petrographic composition and sorption properties, degree of saturation of soils and eventually by presence of other contaminants. Within the applied research conducting simultaneously with maintenance of the airport Hradčany (the largest locality polluted with oil substances by its area), the use of dependence between the summary content of oil substances in soil dry matter (Cz) and the content of these substances in water extract (Cv) was tested. It is the dependence that is statistically significant and expresses integral conditions of mobility of these substances in real hydrogeological conditions. The contribution was concentrated on the processing of the methodology of the usage of these parameters.

hazard analyses; oil contamination; mobility of substances

INTRODUCTION

In hydrogeological practice of removing of old ecological loads in the Czech Republic for evaluation of the necessity of implementation of maintenance works, the criteria taken in 1992 from the Netherlands are used. The degree of contamination, and hence also an ecological hazard, are assessed by the concentration of a substance comprised in soil dry matter (Cz). No such a work dealing with explanation of a suitability of the use of this procedure and the elaboration of new procedures has been published till now.

Ecological hazards, however, cannot be evaluated only on the basis of the knowledge of the data on the contents of a substance in soil dry matter (Cz) (L a n d a , 2000; W i t t l i n g e r o v á , 1996, 1998a, b; W i t t l i n g e r o - v á et al., 1994; W i t t l i n g e r o v á , L a n d a , 2001) for the following reasons:

– it does not take into account the effect of petrographic composition (the percentage of clay minerals) and the percentage of present organic admixtures in soil determined e.g. as the total concentration of organic carbon,
– comprehension of hazard of substances is not uniform in all regulations,
– it does not take into account that not the concentration of an element, but migration form of contaminant decides upon the health and hygienic risks,
– it does not respect different migration capacities of different migration forms of a contaminant.

These are only some major factors that show that the parameter Cz is, as we mean it, suitable only as an auxiliary parameter (Wittlingerová, Jonáš,, 1999; Landa, Wittlingerová, 2000) of soils and different hydrogeological bodies (drain systems, semi-insulators). Main parameters include migration effective porosity of soil ne for concrete migration form of a substance.

In addition, we start from the prerequisite that sorption in homogenous collectors in microdispersion expressed by Henry's isotherm can be included in calculations in such a way that simple substitution is used for prognostic evaluation of distribution of a contaminant. Parameter of migration porosity for not-sorbing substances n (sometimes denoted as an active or open porosity) is substituted by porosity expressing migration of sorbing substances ne in all relationships as well as in mathematical models, i.e.:

$$n => n_e = n + \Delta n = n + \rho_h\, Kd,$$

where: ρ_h – weight density of soil, $\Delta n \equiv \rho_h\, Kd$ – supplementary migration capacity of collector that is not dependent on absolute concentration, nor on continuous or phon contamination of soils. It follows from this relationship that $Cz = \rho_h\, Kd\, Cv$ and also that $Cz/Cv = \rho_h\, Kd = \alpha = H_k$.

Distribution coefficient Kd can be detected also under laboratory conditions in such a way that we let to act water solution of different concentrations of a substance on undisturbed soil sample under the conditions close to expected conditions on the studied locality, up to the creation of the balance. After forming the balance we detect concentration of a substance in soil and in water solution and we plot the curve in co-ordinates $[Cz - Cv]$. This dependence is usually linear under lower concentrations. It is an analogue of tests of extractability by its way with a difference that we do not disintegrate the sample.

Parameter n_e is usually exceeding 1 in real conditions, and therefore the value of active porosity (n) can become negligible in ratio to parameters (Kd). In accordance with the Czech terminological tradition it is denoted as effective migration porosity n_e. In Anglo-Saxon literature (Freeze, Cherry, 1979; Domenico, Schwartz, 1990) it is then denoted as the coefficient of retardation or retardation factor R. As this term better describes the physical entity because it expresses ability of delay of distribution (retardation) of the given substance in soil, further, we will remain to use the term coefficient of retardation R.

This isothermal conception gives a possibility in calculations of distribution of contamination to analyse also the conditions of ion exchange and the effect of biodegradation. In the parameter Kd we take into account also an effect of production of complex soils (Mironěnko, 1992). In real conditions, when contamination solution is formed by a mixture of anions, cations and macro-elements, the function defining the conditions for contamination interface under the effect of pH and temperature in the system "the solid phase – water solution – gaseous phase" may be, however, much complicated. Therefore, the given substitution can be used, if no results of monitoring of waters and control soil samplings are available, only for preliminary calculations. Practical meaning of the usage of the given substitution that a simple analytical solution of basic differential equations derived for not sorbing substances can be used when solving the tasks associated with maintenance works.

In practice under lower concentrations the conception of linear equilibrium between the content of a substance in soils and in water is sufficient. Under lower concentrations of undesirable substances and lower sorption capacity of soils, more general non-linear dependence defined by e.g. Langmuir isotherm $C_z = A\, C_{zmx}\, C_v / (1 + A\, C_v)$, where A – sorption coefficient and C_{zmx} – maximum amount of substance that can be sorbed, is valid. If C_v concentration in water (water extract) is high, $AC_v > 1$ and concentration of sorbed substance correspond to theoretical maximum $C_z = C_{zmx}$.

It follows from the above that to know the value of the parameter R is decisive when ecological hazards are assessed. Some of the following procedures can be used in it:

The value of the retardation coefficient R can be determined on the basis of evaluation of monitoring and $R_I = v_n/v_s$, where v_n and v_s – rate of distribution of not sorbing and sorbing substances and it is determined physically how many times the not-sorbing substance is distributing faster than the sorbing one.

The parameter R that can be calculated on the basis of the laboratory determination of specific weight of dry soil rh corresponding to average weight of rock skeleton, and open porosity no we incorporate into the relationship $R_{II} = 1 + (\rho_h / n_o)\, K_d = n_o + \rho_v\, Kd$. In case that the results of monitoring are available, the parameter Kd can be calculated from the relationship $Kd = ((v_n/v_s) - n_o) / \rho_h$ and or to use the value Kd (ml/g or l/kg) that are tabulated for different contaminants and concrete conditions (usually for

pH = 7.0 and temperature T = 25 °C). They can be calculated for different types of organic compounds, e.g. according to the known relationship. A disadvantage of similar values is that they are determined for relatively low concentrations of solutions of only one substance in an ideal porous material. In the case that real conditions are different from the conditions given in tabular value, the tabular values cannot be used in calculations.

When calculating the value R, we start from the conception that at equilibrium sorption when contaminant comprised in low concentrations in water solution is sorbed on the surface of solid phase (grains), the first, in accordance with linear Henry's isotherm for porous medium, we get the relationship $H_K = \Delta C_z/\Delta C_v = const = \rho_h\ Kd$ (mg/kg)/(mg/dm^3), then $R_{II} = n_o + H_K$ is valid, where Henry's constant H_K is expressing that the ratio of the growth of absorbed substance in the solid phase of soil ΔC_v in solution is constant and K_d – coefficient of volume sorption distribution of substance (distribution coefficient) is expressed in cm^3/g or mg/g, i.e. in dependence on the scale of co-ordinates. Henry's constant for transfer of a substance from liquid phase into gaseous one can be expressed as dimensionless or in the case of expression of volatility of organic substance in atm.m^3/mol etc.

For crack collectors, where specific area of blocks of crack is applied, $H_K = S_b\ K_a$ is valid, where K_a – coefficient of sorption distribution of substance on the surface of the crack (cm) and Sb – specific surface of cracks or blocks (cm^{-1}). Henry's constant of the given substance in rock medium represents the slope (a) of the linear isotherm or the first derivative (tangent) of this empirical curve in co-ordinates $[C_z - C_v]$. If the dependence is linear, then $R_{III} = n_o + (C_z/C_v) = n_o + \alpha = n_o + \Delta C_z/\Delta C_v$ is valid.

When determining the parameter R in further variant, we start from the following relationship: $R_{IV} = n_o + (C_z/C_{pv}) = n_o + \alpha_{IV}$, where: C_z, C_{pv} – concentrations of substance in non-disturbed sample situated below the level of groundwaters and in groundwater. To linearize the relationship, it is possible to use the co-ordinate system $[\log C_z - \log C_{pv}]$ or for better lucidity $[\log C_{pv} - \log C_z]$, respectively.

The use of the given relationships to calculate the retardation coefficient R will give the different results. In the first case (I) it is the application of the effect of all migration processes acting on macro-level in the so-called contamination phase, where contamination cloud is only widening. The calculating R can be computed in the similar way for decontamination phase under action of desorption, degradation with manifestations of maintenance measures. In the second case (II), only the processes that can be theoretically manifested on micro-level are affected. In the third case (III) laboratory conditions and in the last case (IV), then the conditions in the given drain are expressed.

If the value R_I better grasps the actual conditions on the site, then R_{II} is characterising application of the sorption only, what is a theoretical prerequisite that is not usually fulfilled in real conditions, even in the case of contamination of relatively homogenous sandy soils. Advantage of the use of the procedure R_I consists in its simplicity, disadvantage is the necessity of the results from reliable monitoring works. The given equilibrium relationships in the case of application of sorption, ion exchange and biodegradation are manifested in real structures in conclusion of the kinetic phase of distribution of contamination. This phase can last even several years, and hence the results of migration tests oriented to determination of sorption parameters cannot be used. To calculate ecological hazard, it is suitable to use, despite some restrictions, the relationship R_{III}, though partial or full disintegration of the sample can appear in laboratory analyses, therefore the values calculated in this way are overestimated, but from the other side, they are of better security. Parameter R_{IV} can be used at lower concentrations of contaminant. The experience, however, shows that contamination is much heterogeneous and taking of undisturbed rock samples and determination of the most suitable sampling site is much problematic.

In long-term contamination the kinetics of sorption processes is not manifested and the contents of the substance in groundwater are constant. Therefore, systematic appreciation of long-term monitoring of the whole spectrum of sorbing and not-sorbing contaminants on old ecological loads is of decisive importance. Consequently, the relationships R_I and R_{IV} can be used. Disadvantage of such procedure is higher technical and time demandingness and possibility of distortion of the results in cases of stabilisation of contamination cloud, when the rate of its distribution is limiting to zero. Thus, the parameter R_I loses the physical meaning.

Advantage of the use of parameters R_I is that they allow to do calculations of ecological hazard with the use of integral value K_d. In concrete conditions they reflect the best, e.g. the effect of petrographic composition, hydrogeochemical conditions, elimination diffusion processes on micro-meso- and macro-level, the effect of biodegradation, dissolution, precipitation, flowing out, etc. on ecological hazard. Parameter R_{III} that due to conditions of analyses (crushing of the sample) is much lower than R_I then allows qualitative appreciation under the ideal conditions of transition of the substance from solid into liquid phase.

MATERIAL AND METHODS

When elaborating the methodology, we were concentrated on the procedure of calculation of the parameter R_{III}. We started from standard laboratory

procedures that are used for evaluation of contaminants both in soil dry matter and in water extract. The concentration of oil substances determined in laboratories like NES (non-polar extractable substances) were detected in infrared spectrum. Within works, bore holes were hollowed out from which soil samples were taken of the weight of about 200 g. The weight of a sample was determined on sampling sites in dependence on the petrographic composition. In the cases of gravels, we started from the prerequisite that $N = 100$ particles at least should be comprised, i.e. at the weight of grain about 10 g the weight of sample was 1 kg. The NES content was determined both in dry matter (Cz) of disintegrated sample and in water extract (Cv). The extract lasted 48 hours.

For evaluations, we can start from three variants, when NES concentration in sample (Cz) is:

a) significantly higher than the NES weight that can be bound theoretically on the surface of grains in passive pores, diffusely penetrates or is bound to clay minerals ($Cz > Cz_{mx}$). This was a group of samples from the sites with intensive contamination, with pores filled with mobile phases of oil substance. This is a group of samples from sites with intensive contamination, with pores filled with mobile phases of oil substance. This case is typical for samples on the interface of the zone of aeration and saturation, where a free product floats on the level of groundwaters. Contents in water extract (Cv) can be considerably high and may significantly exceed the value of solubility NES. An important identification criterion is that when a sample was embedded with water NES is released without its disintegration and mixing and a film or layers of a product appear on the water level with which the sample was watered. A part of NES can be washed out from the sample of soil. In this case NES values represent an ecological hazard with respect to mobility and dependence on concrete hydrogeological conditions. In sampling probes and monitoring drill holes the rise of phase on the level of groundwaters can appear immediately after mounting. In prognostic calculations it is suitable to orientate to calculations of distribution of contamination cloud consisted of the both the product itself (the phase of oil substance) and soluble substances. Out of maintenance methods it is appropriate to use the methods of water and air extraction.

b) comparable with the weight of a substance, bound on the surface of grains and in passive pores ($Cz = Cz_{mx}$). In these cases concentration equilibrium can occur between NES contents in water extract (Cv) and in dry matter (Cz) and linear dependencies interlarded by experimental points can be constructed, hence expressing the ecological hazard. For preliminary calculations of ecological hazard analytical relationships derived for not-sorbing substances and to introduce parameter á into calculations of NES distribution, whose structure and physical meaning is identical with

Henry's constant (H_K), determined in laboratory conditions for different petrographic types of rocks. The importance of the use of the coefficient á consists in the fact that it takes into account integrally the effect of all factors acting on the given set of data. It allows a good transition from experiment on micro-level (sample) to real conditions on macro-level (drain, well). In dependence on the conditions of a locality it is appropriate to prefer methods of controlled biodegradation.

c) lower than weight of NES values that can be bound maximally in the sample ($Cz < Cz_{mx}$). The NES content in water extract (Cv) and at high concentration in soil dry matter (Cz) is usually stable. The NES contents in soil hence mean a low ecological hazard. In the case of starting maintenance works, it is necessary to prefer methods of natural attenuation before other methods.

We can meet all the cases mentioned above in one locality. It is valid that theoretical value Cz_{mx} (maximum obtainable weight of a substance bound in the rock) usually grows with the fall of mobility of contaminant, NES in our case. Very low mobility will be in viscous and little soluble organic substances. It is valid that the lower the percentage of volatile substances in the given group NES, more oxidised of organic substance, biodegradable fractions degraded, the lower the content on a contaminant in water extract (Cv), the higher maintenance limit of residual contents of NES in dry matter of soils can be approved.

The results of the different parts (fields) of the locality Hradčany (military airport in North Bohemia) were evaluated in summary in such a way that coefficient $\alpha = Cz/Cv$. Such arisen set of data was classified in descending order according to the size of Cz, Cv and α. Then the graphs were constructed for different variants in normal and logarithmic co-ordinates. In the case of the results of the NES content in groundwaters and in soil sample under the level of groundwaters the results were evaluated for different fields.

RESULTS

The results are processed in the following groups:

Group I comprises the results of evaluation of the content of NES concentration in the soil (Cz) and in groundwater (Cpv) with an aim to find the possibility of the use of procedure for the calculation of R_{IV}. In harmony with the above methodology dependencies co-ordinates $Cpv = Cz$ were constructed the first. However, they manifested rather great dispersion. Therefore the graphs in co-ordinates [log Cpv – log Cz] were constructed for different maintenance fields that differ by both time for which they are maintained and
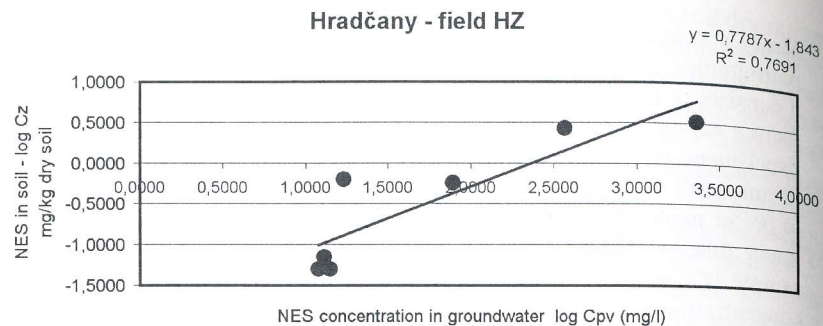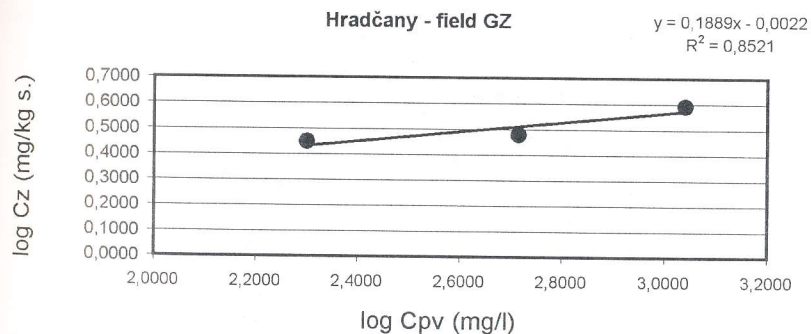
Hradčany - field HZ

$y = 0,7787x - 1,843$
$R^2 = 0,7691$

1. Dependence of the NES content in groundwater and soil near the groundwater table (field HZ)

Hradčany - field FZ

$y = 0,2976x - 0,3511$
$R^2 = 0,2395$

2. Dependence of the NES content in groundwater and soil near the groundwater table (field FZ)

Hradčany - field EZ

$y = 0,5508x - 1,5104$
$R^2 = 0,3058$

3. Dependence of the NES content in groundwater and soil near the groundwater table (field FZ)

Hradčany - field GZ

$y = 0,1889x - 0,0022$
$R^2 = 0,8521$
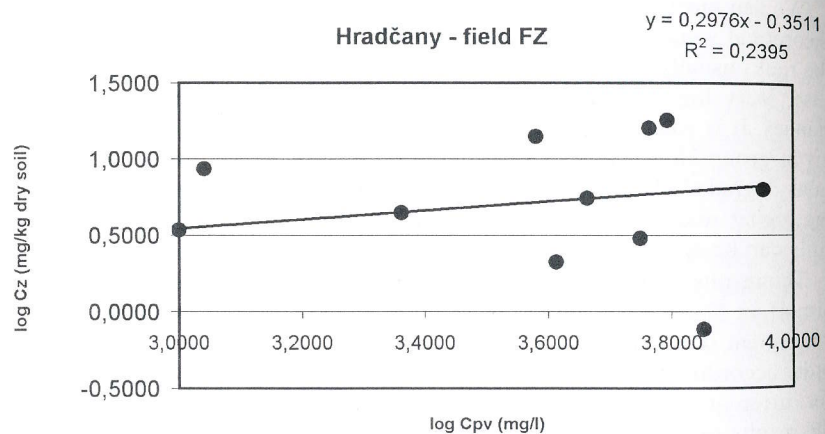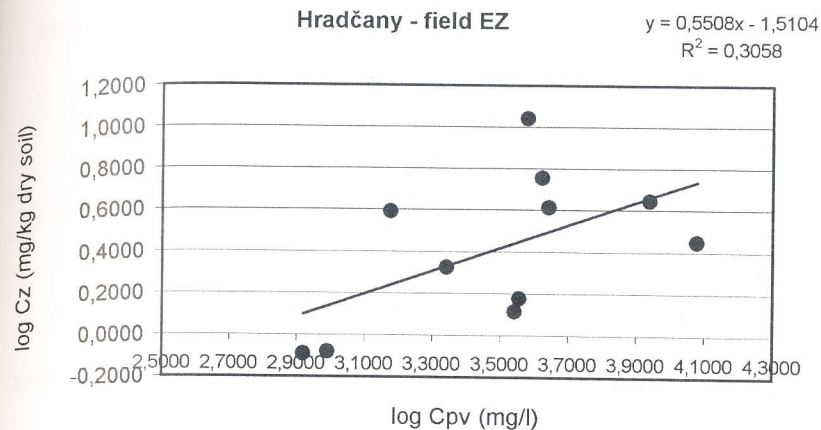
4. Dependence of the NES content in groundwater and soil near the groundwater table (field GZ)

by petrographic conditions. Fig. 1 (the field HZ on the locality Hradčany) shows that the coefficient of reliability is relatively high $R^2 = 0.7691$) the same like the value of coefficient $\alpha = 0.7787$. In other fields, i.e. FZ (Fig. 2), EZ (Fig. 3), BVZ (Fig. 5), however, the coefficient of reliability is very low (below 0.3), while in the field GZ (Fig. 4), even despite high $R^2 = 0.8521$, the results can be considered as non-reliable for a small set of samples. The set of all data (65 samples) is then processed in Fig. 6. It is very interesting by the fact that the correlation curve of parabolic form can be fit. According to BVZ, where the coefficient R^2 is very low, the field, where maintenance

takes place for a long time using water and air extraction with initialisation of natural biodegradation processes by supplying of oxidized water and nutrients. Hence, existing balance between the contents of underground water in soil was disturbed.

The second group comprises not classified results processed for different concentration interfaces up to 0.5 g/kg dry matter (Fig. 7), what is a criterion value A (see above), up to 5 g/kg dry matter (Fig. 8), then the value limiting deposition of contaminated soils in disposals without stabilisation. Neither from this graph it follows that there is some correlation dependence, and thus,
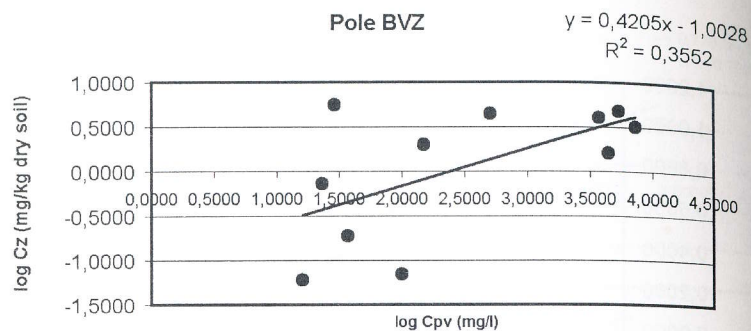
Pole BVZ

$y = 0{,}4205x - 1{,}0028$
$R^2 = 0{,}3552$

5. Dependence of the NES content in groundwater and soil near the groundwater table (field BVZ)


The set of all data (65 samples)
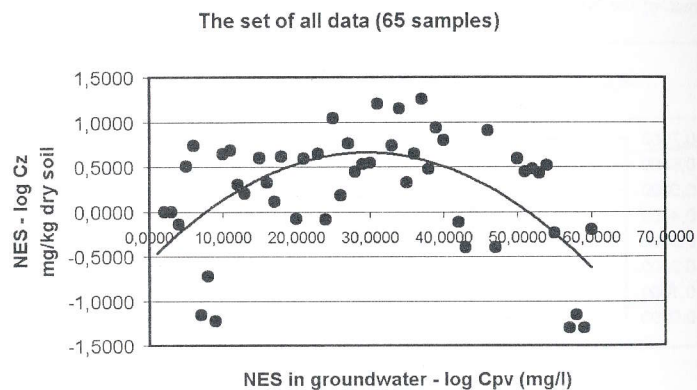
6. Dependence of the NES content in groundwater and soil near the groundwater table (all set)

that it could be possible to calculate coefficient α, and hence also R_{III}. It is evident from Figs. 9 and 10 that certain group of samples can be detached, which could contain highly above-limit NES contents in water extract exceeding by several orders the limit of solubility NES in water. It can be concluded from this, that the set comprises even the samples from the sites where despite relatively low NES contents in soil dry matter jet fuel in the phase occurs with a great probability.

The results of analyses are processed in the third group, where the set of samples was classified into different groups by the value of water extract.
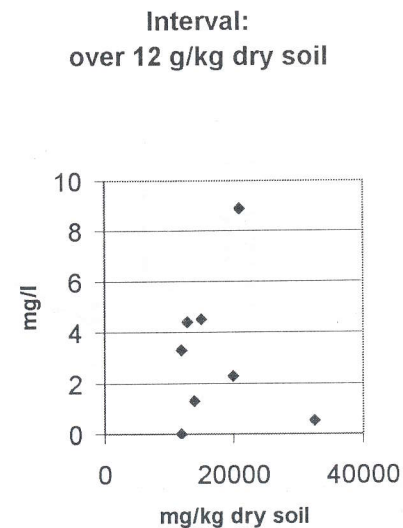

Interval:
0 - 500 mg/kg dry soil

Interval:
0,5 -5 g/kg dry soil
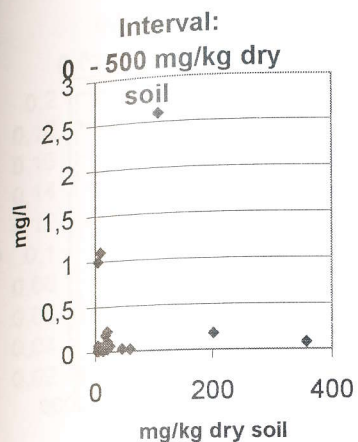
7. Dependencies between the NES content in soil dry matter and water extract – interval: 0–0.5 g/kg dry soil
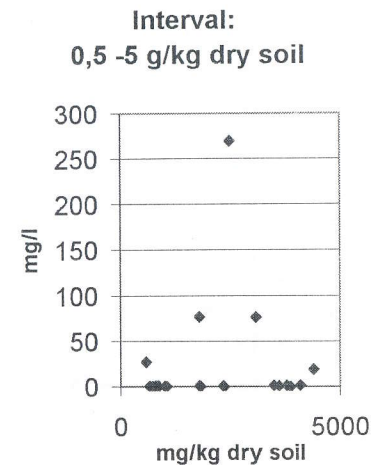
8. Set in interval values 0.5–5.0 g/kg dry soil

Interval:
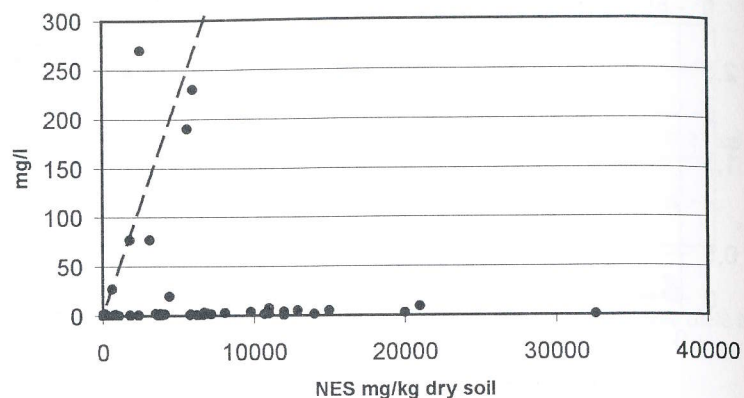5 - 12g/kg dry soil

Interval:
over 12 g/kg dry soil
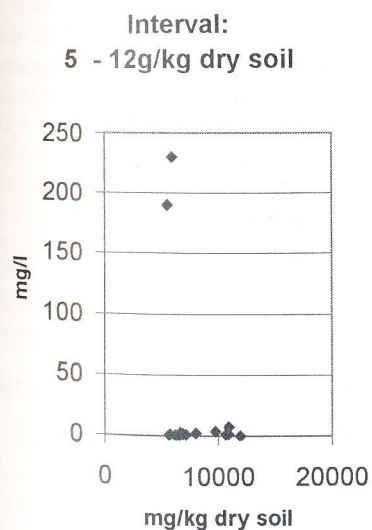
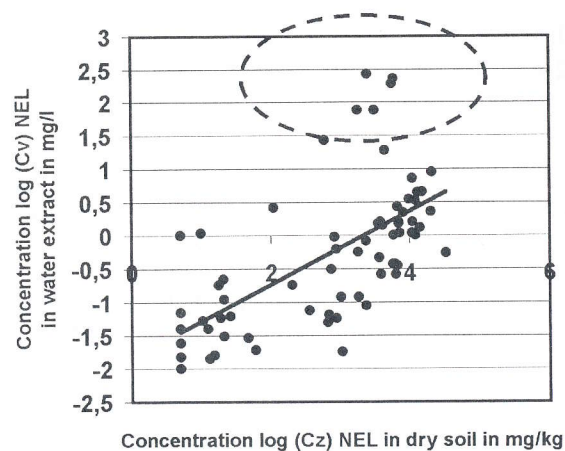9. Set in interval values 5–12 g/kg dry soil

10. Set in interval values over 12 g/kg dry soil

The set in interval 0 - 35 g/kg dry soil - (67 samples)

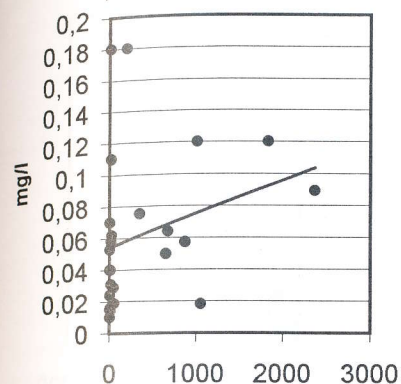11. Set in interval values over 0–35 g/kg dry soil

The whole set of data (67 samples)
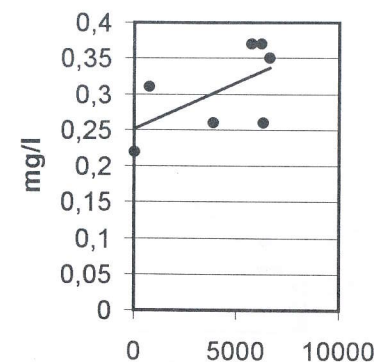
12. Dependence in co-ordinates log (Cz) – log (Cv)

Correlation is relatively low ($R^2 = 0.3281$) in lower interval of values (Fig. 11) and is rising gradually ($R^2 = 0.5423$) (Fig. 12). In other groups (interval 0.4–0.5 mg/l – Fig. 13, and the above Fig. 14) is then negligible.

Interval: 0,01 - 0,2 mg/l

13. Set in interval values over 0.01–0.2 mg/l water extract
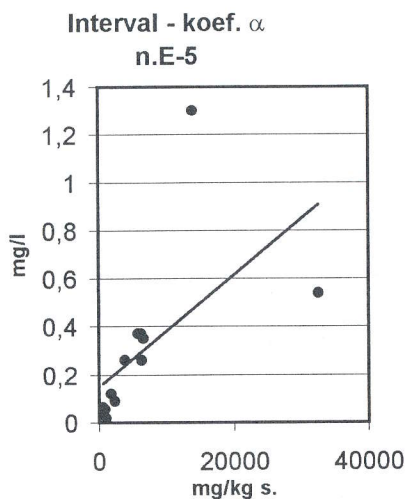

Interval: 0,2 - 0,4 mg/l

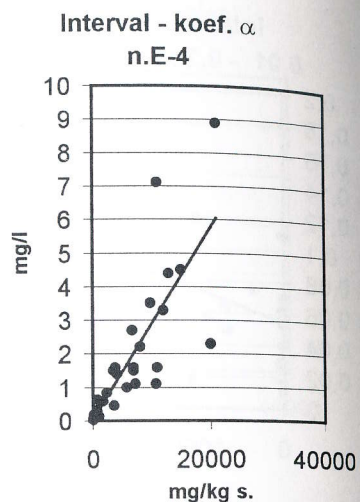14. Set in interval values over 0.2–0.4 mg/l water extract

The results of analyses are processed in the fourth group in such a way that they are classified by the size of the coefficient α, whose value is expressing, the first of all, an eventual percentage of less soluble fractions of oil carbohydrates. It is interesting in this connection that at very low values ($\alpha = n.E–5$) the dispersion of the values is relatively high (Fig. 15). Correlation is rising gradually, reaching $\alpha = n.E–4$ ($R^2 = 0.523$). If we detach from the set the samples corresponding to the presence of the NES phase (petrol fuell for airplan) and we assess a remaining new set, then it is evident that an analysed set contains two to three groups of samples with application of different factors in the given case at water extract up to 4.5 mg/l, e.g. soils with percentage of easily, medium releasable and non-releasable oil substances (Figs. 19 and 20).

DISCUSSION
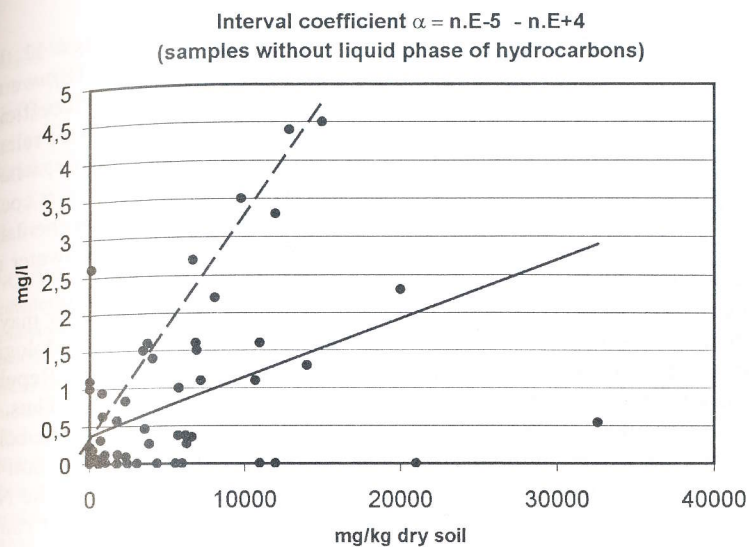
The results of analyses (C_z, C_v) and calculation of the coefficient α show that according to the shape of curves and dispersion of the values, it can be judged on ecological conditions affected by the presence of organic compounds of the NES group. A good mutual ability to correlate is visible at relatively low extracts within the interval 0.2–0.4 mg/l. With rising share of a product of organic substance in pores and mainly by application of maintenance processes, data are dispersed and two to three different groups of
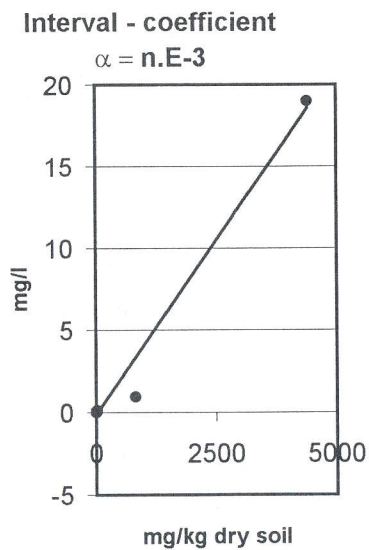
Interval - koef. α n.E-5

15. The order values *n.E–5*

Interval - koef. α n.E-4

16. The order values *n.E–4*

Interval - coefficient α = n.E-3

17. The order values of coefficient α = *n.E–3*

Interval - coefficient α = over n.E-2

18. The order values of coefficient α = *n.E–2*

Interval coefficient α = n.E-5 - n.E+4 (samples without liquid phase of hydrocarbons)

19. The whole set of data (samples with extract of NES up to 5 mg/l)

Interval of coeficient α = n.E-5 - n.E+4 (samples with liquid phase of hydrocarbons)
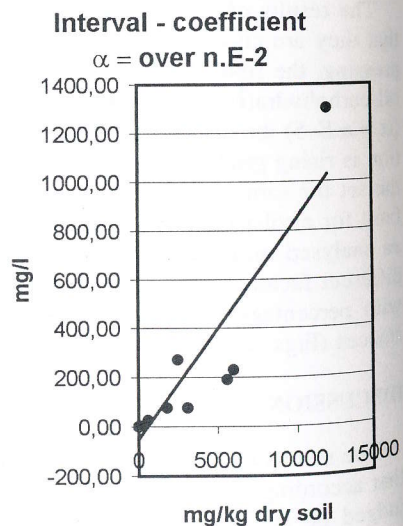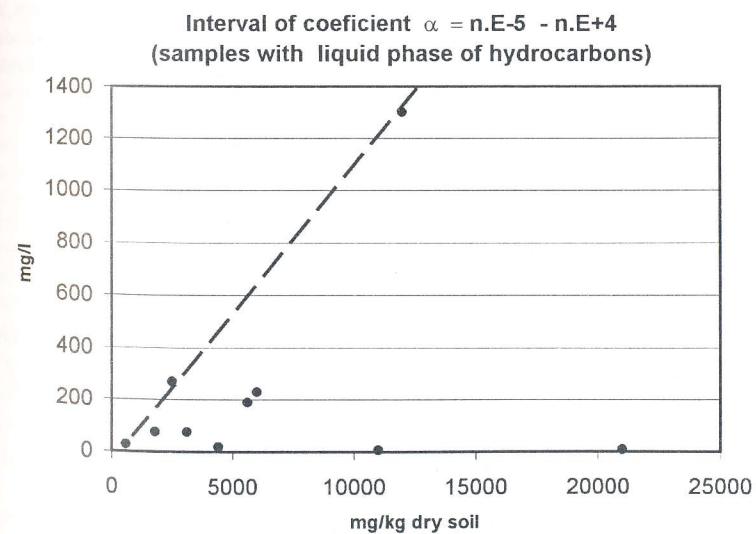
20. The whole set of data (samples with extract of NES over 5 mg/l)

samples are defined, eliminating reliable single curve fitting (Figs. 11, 12). If we group the set by the value of the coefficient α (Figs. 15–18), we can use the value α, obtained in this way, for framework calculation of coefficient of retardations (R_{III}). This value can be then used for calculations of relative rates of distribution of a substance in different parts of the territory, what is expressed by the map or section of the territory with the values of α coefficient. It is always useful for comparison to use also the results of the calculation of α coefficient calculated from the NES contents in groundwater and soil that we use then also for calculation (R_{III}).

The results of the work show that NES contents in soil dry matter may be higher in orders than those settled by present regulations and methodological recommendations of the Ministry of Environment of the Czech Republic without exceeding acceptable ecological risk in the given locality. Thus, for example it can be seen from Figs. 20 and 21 that water extract may be below 2.5 mg/l even at very high NES contents ranging from 15 to 35 g/kg soil dry matter. For the given locality it is even valid that with the rise of the NES contents in soil dry matter the values of water extract are falling. It can be explained by the fact that at biodegradation of NES the resulting product is, except carbon dioxide and water, also an organic matter. With growing of its share, sorption properties of the soil are increasing and simultaneously with it, the share of NES phase is falling, which is consumed as a source of carbon during the biodegradation itself. It means that mobile carbohydrates are gradually microbiologically transformed into organic matter that is not only less mobile, but on the contrary it improves the conditions of sorption of these carbohydrates in soil.

CONCLUSION

The proposed procedure of evaluation of the ecological risk consists in the fact that in taken samples divided into different groups by the degree of saturation with water or organic substance and petrographic composition of soils in the given locality, we construct the curves in co-ordinates $[Cz - Cv]$ or $[\log Cz - \log Cv]$. According to the shape we can judge how is the effect of soluble or less soluble fractions of oil carbohydrates and the effect of higher share of carbon comprised in organic matter produced during biological NES degradation. Then we fit an empirical line for suitable concentration range and calculate the first the coefficient α and with the aid of it then also the coefficient of retardation R_{III}. We compare this parameter eventually for the results of calculations using the long-time monitoring of the quality of waters (R_I). We do the substitution in calculation relationships $n => R_I$ or n_e, respectively, in dependence on concrete hydrogeological conditions and as a

prognosis we calculate the rate of distribution of contamination and decontamination cloud and we assess the ecological risk. We use this procedure in a proposal of maintenance limit when the allowed content of substance in dry matter Cz we calculate according to the values of water extract Cv found and calculated coefficient α.

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Ekologické zátěže a kritéria znečištění zemin.

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Při posuzování stupně znečištění horninového prostředí na starých ekologických zátěžích jsou používány legislativní předpisy a metodická doporučení, v nichž jsou tabelizovány limitní hodnoty kontaminantů jak v zeminách, tak i podzemních vodách. Rozlišují se tři základní kategorie limitních hodnot (A n o n y m u s , 1996a) koncentrace látky v sušině zeminy (Cz, v mg/kg sušiny) vyjádřené písmeny: A – limit pro pozaďové znečištění, který prakticky vychází z indikační schopnosti dané analytické metody, B – limit pro běžné přírodní podmínky, limit C – jeho překročení znamená, že je nutno zahájit speciální průzkumné práce zaměřené na stanovení podmínek a rozsah znečištění s cílem navržení sanačních a ochranných opatření. Tyto základní limity jsou určeny odděleně pro průmyslové, obytné a rekreační oblasti. Pro zemědělsky využívané půdy platí limity dané vyhláškou MŽP č. 13/1994 Sb. (A n o n y m u s , 1994).

Limity pro obsahy látek v sušině (A n o n y m u s , 1996a) však neumožňují posoudit reálné ekologické nebezpečí přítomnosti daného kontaminantu v zeminách a v podzemní vodě. Proto jsme aplikovaný výzkum zaměřili na výběr kritérií, která by lépe umožňovala hodnotit rizikovost znečištěných pozemků, byla průkazná a jejich kontrola operativní a ekonomická. Ukázalo se, že závislost mezi celkovým obsahem látky v sušině Cz (mg/kg sušiny) a ve vodném výluhu Cv (mg/l) může být za určitých podmínek vypovídající, neboť tvar křivek v souřadnicích [$Cv – Cz$] anebo [log Cv – log Cz] umožňuje vyhodnotit potenciální mobilitu kontaminantu. Významným kritériem pro hodnocení ekologického rizika je pak koeficient úměrnosti (α) empirické závislosti $Cz = \alpha\ Cv$, resp. log $Cz = \alpha_{log}$ log Cv. Čím vyšší je jeho hodnota, tím vyšší je potenciální mobilita dané látky a ekologické riziko, přičemž lze tento parametr použít i pro prognózní výpočty šíření ropných látek v podzemních vodách. Ověření použitelnosti tohoto parametru bylo uskutečněno v letech 1999–2000 na souboru vzorků zemin kontaminovaných leteckým petrolejem na lokalitě Hradčany.

Závěrem konstatujeme, že pro komplexní hodnocení kontaminovaného horninového prostředí nestačí analyzovat pouze obsahy látek v sušině zemin tak, jak je tomu doposud, vzhledem k tomu, že tento údaj nevyjadřuje stupeň uvolnitelnosti látky (sorpci a desorpci) ze znečištěné zeminy. V tomto smyslu je navrženo dopracování metodiky pro posouzení kontaminovaných zemin na starých ekologických zátěžích.

rizikové analýzy; ropné znečištění; mobilita látek

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