Editorial Board

Chief Editor: Prof. Dr. eng Miho Mihov

Responsible secretary: Corresp. Memb. Prof. D.Sc. Hristo Beloev

Members:

Acad. D.Sc. Jemal Katsitadze – Georgia
Acad. D.Sc. Sayakhat Nukesheev - Kazakhstan
Acad. D.Sc. Volodymyr Bulgakov – Ukraine
Acad. D.Sc. Valeriy Adamchuk – Ukraine
Prof. Abdullah Sessiz - Turkey
Prof. Abdulrahman Al-soqeer - Saudi Arabia
Prof. Alexander Tokarev - Russia
Prof. Alexey Vassilev - Russia
Assoc.Prof. Angel Trifonov - Bulgaria
Prof. Anupam Kumar Nema - India
Prof. Ayrat Valiev - Russia
Prof. Barbro Ulén - Sweden
Prof. Carmen Puia - Romania
Prof. Cheslav Vashkievich - Poland
Prof. Cumhur Aydinlalp - Turkey
Prof. Daisuke Higaki - Japan
Prof. Davor Romic - Croatia
Prof. Domenico Pessina - Italy
Dr. Finn Plauborg - Denmark
Assoc.Prof. Ganka Baeva - Bulgaria
Assoc.Prof. Georgi Mitev - Bulgaria
Prof. Georgi Tassev - Bulgaria
Prof. Haiyan Huang - China

Members:

Prof. Hoang Thai Dai - Vietnam
Prof. Illya Malinov - Bulgaria
Assoc.Prof. Ivan Ivanov - Bulgaria
Prof. Jan Szczepaniak - Poland
Prof. Komil Muminov - Uzbekistan
Prof. Krassimira Georgieva - Bulgaria
Prof. Maja Manojlović - Serbia
Prof. Mihail Iliev - Bulgaria
Prof. Mohammad Salem Al-Hwaiti - Jordan
Prof. Papamichail Dimitris - Greece
Prof. Pavel Tlustos - Czech Republic
Prof. Plamen Kangalov - Bulgaria
Prof. Ralph Meissner - Germany
Prof. Rossen Ivanov - Bulgaria
Prof. Svetla Rousseva - Bulgaria
Prof. Tadeusz Pawłowski - Poland
Prof. Tamara Persikova - Belarus
Prof. Valentina Kundius - Russia
Prof. Wojciech Tanaś - Poland
Prof. Yerbol Sarkynov - Kazakhstan
Prof. Zdenko Tkach - Slovakia
Prof. Zinta Gaile - Latvia
Prof. Zivko Davchev - Macedonia
CONTENTS

MECHANIZATION IN AGRICULTURE

STUDY OF SPECIAL ASPECTS OF HITCHING TO WIDE SPAN TRACTORS (VEHICLES)
Prof. Doc. Ing. Volodymyr Bulgakov, PhD; Prof. Doc. Ing. Margus Arak, PhD; Prof. Doc. Ing. Jüri Olt, PhD;
Prof. Doc. Ing. Ivan Holovach, PhD; Doc. Ing. Volodymyr Kuvachov, PhD ........................................................ 111

METHODOLOGY OF EVALUATION OF ENVIRONMENTAL AND TECHNOLOGICAL PROPERTIES
OF THE MOBILE ENERGY MACHINE
Assis. prof. Eng. Vasil Mitkov PhD, Prof. Eng. Hristo Beloev ................................................................. 114

CONSERVING OF THE RESOURCES

IDENTIFICATION OF SPATIAL VARIABILITY OF SOIL PHYSICO-CHEMICAL PROPERTIES FOR
PRECISION FARMING
Lukas V., Neudert L., Novák J., Paulová N. ........................................................................................................ 117

IDENTIFYING THE PHYSICAL PROPERTIES OF THE SOIL USING PROPER SOIL SOFTWARE
Assoc. Prof. Mitev G. DSc., Asst. Prof. Kalinova S, PhD., Asst. Prof. Bratoev K.PhD. ........................................ 120

ACTUALITY OF THE PROBLEM OF WATER DEPURATION OF THE DNIEPER ACCORDING TO
THE THEORY OF SOCIAL WELFARE
Prof. D. Skrypnyk A., PhD Stud. Holiachuk O. ............................................................................................. 127

THE INFLUENCE OF SOIL MICROELEMENTS ON SULPHUR CONTENT IN THE SPRING WHEAT
Dr. Brazienė Z., Dr. L. Aleknavičienė ............................................................................................................. 131

ROAD EFFECTS ON VEGETATION COMPOSITION AND SOIL PROPERTIES IN GOL-E-GOHAR
REGION (KERMAN PROVINCE, IRAN)
Naseri H.R, PhD., M.Sc. Shahbodaghi J, PhD., Yousefi Khanghah S , PhD., Baba Akbari M,
M.Sc., Iman Atighi ........................................................................................................................................... 135

POTENTIAL REUSE OF TREATED INDUSTRIAL WASTEWATER IN AGRICULTURE: TEXTILE
WASTEWATER
Dr. Özkaraova E. B., Dr. Akbal F., Dr. Kuleyin A. ........................................................................................... 138

PROTECTION OF SOILS AND WATER RESOURCES AS AN IMPORTANT FACTOR IN FORMING
PREPARATION TO THE PROJECT ACTIVITY OF FUTURE AGROENGINEERS IN INSTITUTIONS
OF HIGHER EDUCATION
Candidate of Technical Sciences, Associate Professor Viktor Pryshliak ........................................ 141
STUDY OF SPECIAL ASPECTS OF HITCHING TO WIDE SPAN TRACTORS (VEHICLES)

ИССЛЕДОВАНИЕ ОСОБЕННОСТЕЙ АГРЕГАТИРОВАНИЯ МОСТОВЫХ ТРАКТОРОВ

Prof. Doc. Ing. Volodymyr Bulgakov1, PhD; Prof. Doc. Ing. Margus Arak2, PhD; Prof. Doc. Ing. Jüri Olt2, PhD;
Prof. Doc. Ing. Ivan Holovach1, PhD; Doc. Ing. Volodymyr Kuvachov3, PhD

1 National University of Life and Environmental Sciences of Ukraine,
2 Estonian University of Life Sciences
3 Tavria State Agrotechnological University

E-mail: vbulgakov@meta.ua

Abstract. The paper presents the research into the specific aspects of hitching agricultural machines and implements to wide span tractors (vehicles). According to the results of the performed investigations, the redistribution of the normal reaction forces on the tractor’s front and rear wheels depends to a significant extent not only on the inclination of the hitch links of the wide span tractor (vehicle), but also on such design parameters as the distance from the linkage to the centre of resistance and the carrier wheel of the agricultural machine or implement. In order to exclude in practical terms completely the effect of the machines’ running gear compacting the soil in the yielding (agronomic) zones of the field, it is recommended to implement on the wide span tractors (vehicles) the controlling devices that allow adjusting the normal vertical load on the agricultural machine or implement’s carrying wheels. Such controlling devices can operate on the principle of the known weight transfer traction boosters used in conventional tractors.

1. Introduction

In view of the rather high versatility of the wide span tractors (vehicles) employed in controlled traffic farming, they can (and surely have to) be ganged up with trailing, semi-mounted and fully mounted agricultural machines and implements [2]. The latter’s weight and tractive resistance can cause substantial redistribution of the vertical loads on the wide span tractor’s wheels. The main problem is that the use of an inappropriate layout in the attachment of agricultural machines and implements to the tractor can result in the situation, where, instead of additionally loading the steering and driving wheels of the wide span tractor (vehicle), their load will be relieved, with all the ensuing consequences. At the same time, the vertical load on the carrier wheels of the attached agricultural machines and implements, which are usually situated in the agronomic (yielding) zone of the field, can increase substantially. Whereby, the excessive compacting of the soil by the machines’ running gear will bring to nought all the benefits from controlled traffic farming.

2. Preconditions and means for resolving the problem

2.1. Analysis of recent research and publications

The accumulated worldwide experience of hitching to wide span tractors (vehicles) proves that they can be used with three-point hitch linkages (Fig. 1). But the research into the design features of the latter in terms of their operation with wide span tractors (vehicles) is given virtually no coverage in the scientific literature. Meanwhile, it is well known that the inclination angles of the central (upper) and lower hitch links of the conventional tractor’s implement-attaching unit have a significant effect on the redistribution of the normal reaction forces acting on the tractor’s wheels. The pattern of the said redistribution of the normal reaction forces on the tractor’s wheels is determined by the design parameters of its hitch linkage and the agricultural machine or implement hitched to it.

Also, it ought to be noted that certain trends have recently been outlined in the improvement of the design of the three-point hitch linkages of tractors. Still, the issue of investigating the effect that the parameters of the hitch linkage installed on a wide span tractor (vehicle) and the layout of the attachment to it of machines and implements have on the pattern of changes in the vertical loads on its wheels is not paid sufficient attention.

2.2. Purpose of the study

The aim of the study was to improve the grip properties, stability and controllability of motion of wide span tractors (vehicles) and also to reduce the compacting of soil in the yielding zone of the field by the machines’ running gear through the substantiation of the parameters of their hitch linkages and the layout of attaching to them agricultural machines and implements.

3. Results and discussion

A wide span vehicle designed in Ukraine (Fig. 2) is taken as the physical object of the investigation.

In order to analyse and solve the set problem, the wide span vehicle is represented by a planar equivalent model (Fig. 3). The tools of the hitched agricultural machines and implements are represented in the model (Fig. 3) by a projection of one tool, in
which the tractive resistance of the machines and implements is concentrated in the form of the resultant force (its horizontal $R_x$ and vertical $R_y$ components). The said equivalent tool is hitched to the wide span vehicle by means of its central and lower hitch links. All carrier wheels that the hitched agricultural machine or implement can have are represented in the schematic model by one equivalent carrier wheel.

![Fig. 3. Schematic model of forces and moments acting on wide span vehicle in longitudinal vertical plane](image)

The moments $M_x$ and $M_y$ (Fig. 3) can be expressed as follows:

$$M_x = (P_a - P_b)l_y,$$

$$M_y = (P_b - P_a)l_y,$$

where $P_a$, $P_b$ – tangential traction forces applied to the front and rear wheels of the tractor, respectively; $P_{a1}$, $P_{b1}$ – rolling resistance forces acting on the front and rear wheels of the tractor, respectively; $r_{a2}$, $r_{b2}$ – rolling radii of the front and rear wheels of the tractor.

Subsequently:

$$P_a = fN_{a1};$$

$$P_b = fN_{b1};$$

where $f$ – coefficient of rolling resistance;

$$\varphi$$ – tractor’s adhesion weight utilization factor.

The force $P_{b1}$ and moment $M_1$ of rolling resistance of the agricultural implement’s carrier wheel can be found as follows:

$$P_{b1} = fN_{b1},$$

$$M_1 = fN_{b1}r_{b2},$$

where $r_{b2}$ – radius of the agricultural implement’s carrier wheel.

Depending on the values of the angles $\alpha$ and $\beta$ of the inclination of the wide span vehicle’s central and lower hitch links, respectively, the coordinates of the linkage’s instantaneous centre of turn ($Z_x$ and $Z_y$) can be expressed in terms of its own design parameters (Fig. 4).

![Fig. 4. Schematic model for determining coordinates of instantaneous centre of turn of wide span vehicle’s hitch linkage](image)

The coordinates of the hitch linkage’s instantaneous centre of turn in accordance with Fig. 4 can be determined as follows:

$$Z_x = h_0 - h_1 \frac{\tan(\alpha) - \tan(\beta)}{\tan(\alpha) - \tan(\beta)},$$

$$Z_y = h_0 - h_1 \frac{\tan(\alpha) + \tan(\beta)}{\tan(\alpha) - \tan(\beta)},$$

where $Z_x$, $Z_y$ – longitudinal and transverse coordinates of instantaneous centre of turn of wide span vehicle’s hitch linkage; $h_0$, $h_1$ – design parameters, the nature of which can be seen in Fig. 4.

The vertical reaction forces $N_x$ and $N_y$ in accordance with the adopted schematic model of acting forces (Fig. 3) and in view of the above are determined as follows:

$$N_x = G_T - Y - N_{\alpha1},$$

$$N_y = G_T - (G_T - Y)\frac{d}{L}X + \frac{d}{L}Z_Y,$$

where $G_T$, $a_T$ – tractor’s weight and the horizontal coordinate of its centre of mass; $M_x$, $M_y$ – moments of rolling resistance of the tractor’s front and rear wheels, respectively; $L$ – wheel base of the tractor; $d$ – distance from the attachment device of the attached agricultural implement to the rear wheel axle of the wide span vehicle;

$h$ – length of a lower link of the hitch linkage.

The choice of the sign “+” or “−” between the last summands in the second equation of the system (5) depends on the position of the hitch linkage’s instantaneous centre of turn (point $x$) with respect to the point $B$. For example, if the moment produced by the reaction forces $X$ and $Y$ rotates in a clockwise sense, then the sign “+” is assumed, otherwise “−” is chosen.

In accordance with the adopted schematic model of acting forces (Fig. 3) and taking into account the above, the unknown reaction forces $X$ and $Y$ as well as $N_x$ are determined as follows:

$$Y = N_x - G_T - R_x,$$

$$X = fN_{b1} + R_x,$$

$$\pm G_x = fN_{b1} + R_x,$$

$$N_x = \pm G_x + \frac{H}{2},$$

where $H$ – depth of tilling of the soil by the agricultural implement;

$G_x$ – weight of the agricultural implement;

$D_r$, $D_y$, $D_z$ – design parameters of the agricultural implement, the nature of which can be seen in Fig. 3.

In the third equation of the system (6), the sign “+” is chosen, when the respective forces produce a moment with respect to the point $x$ (Fig. 3), which rotates in a clockwise sense, otherwise the sign “−” is required.

The systems of equations (5) and (6) provide for finding the optimum values of the angles of inclination ($\alpha$ and $\beta$) of the hitch links as well as other design parameters of the wide span vehicle in terms of the desirable redistribution of the normal reaction forces on its front and rear wheels. The analysis of the mentioned expressions provides evidence that, apart from the angles of inclination of the hitch links, the redistribution of the normal reaction forces acting on the wide span vehicle’s wheels is substantially influenced by such design parameters as the distance from the hitch linkage to the agricultural implement’s centre of resistance ($D_R$) and carrier wheel ($D_z$).

The analysis of the data obtained by mathematical modelling results in the conclusion (Fig. 5) that the degree of redistribution of the normal reaction forces on the front and rear wheels of the wide span vehicle of our design and the carrier wheels of the agricultural implement depends to a considerable extent on the angle of inclination $\alpha$ of the central hitch link.
At a negative angle of inclination $\beta$ of the lower hitch links, the most appropriate set-up of the hitch linkage of the wide span vehicle of our design is when the angle of inclination $\alpha$ of the central link has a positive value of up to 40 deg. In that case, the vertical load on its rear wheels is on the average 1.5 times greater than in the static condition, the normal reaction forces on the front wheels are reduced to 60%, which is acceptable in terms of ensuring the sufficient controllability of the wide span vehicle’s motion in case of the kinematic method of its steering. At the same time, the normal reaction force acting on the agricultural implement’s carrier wheel is desirably reduced or virtually equal to its static value.

However, it ought to be noted that the set-up of a three-link hitch mechanism with a large positive angle of inclination of the central link (reaching 40 deg and higher) and a negative angle of inclination of the lower links can become practicable only after the detailed study of the kinematics of its operation, which can provide the basis for further investigations.

At a positive angle of inclination of the lower hitch links of the wide span vehicle of our design the most desirable set-up of the upper link includes inclination angles within a range of 25 to 35 deg. In this case, a certain decrease in the compacting of the soil in the yielding zone of the field by the agricultural implement’s carrier wheels is observed as well as the weight transfer on the implement’s carrier wheels compacting the soil in the yielding zone of the field. The operating principle of the said regulating device is similar to that of the widely known hydraulic tractor adhesion weight boosters. The latter, as is known, produce the effort needed for lifting the hitch linkage with the mounted agricultural machine or implement. In this process, the position of the instantaneous centre of turn of the hitch linkage remains unchanged. The mentioned provision is observed as long as the magnitude of the force that lifts the agricultural implement does not exceed the level, at which the implement is shallowed up out of the soil.

Alongside with that, it has been established that, in the majority of the possible cases of set-up of the wide span vehicle’s hitch linkage, the relief of the load on its front wheels is observed. In order to increase the said load, which means retaining the sufficient controllability of the wide span vehicle in case of the kinematic method of its steering, it is advisable to place all vehicle-borne process containers possibly closer to its front wheel axle. That will increase the vertical load on the front wheels by adding the weight of the process containers with the materials.
METHODOLOGY OF EVALUATION OF ENVIRONMENTAL AND TECHNOLOGICAL PROPERTIES OF THE MOBILE ENERGY MACHINE

Assis. prof. Eng. Vasil Mitkov¹ PhD, Prof. Eng. Hristo Beloev²

¹Tavria State Agrotechnological University, 18, Khmelnitskyy av., Melitopol, 72312, Zaporizhia region, Ukraine;
²Angel Kanchev University of Rousse, 8, Studentska Str., 7017 Ruse, Bulgaria
E-mail: mitk0lg@gmail.com

Abstract: The method of estimation of technological properties of a mobile power tool is presented in the work taking into account the index of its ecological properties. The results of the expert survey are presented to determine the importance of individual indicators in the evaluation of the generalized indicator of the environmental and technological properties of the mobile energy means. Increasing the informativeness of the methodology for evaluating the technological properties of a mobile power tool by taking into account the generalized index of its environmental properties. The structure of the index of environmental properties of depends on the assignment of the estimated energy source and the purpose of the problem to be solved. In our opinion, with a comparative assessment of energy resources as a unit one can adopt the following indicators of their environmental properties. The obtained result shows that today it is more relevant to assess the technogenic impact of a mobile energy facility on the environment than the cost of its implementation unit of work. And with this conclusion, one can not disagree, since the neglect of the impact on the environment in the near future can nullify the economic profit from the production of agricultural products. The evaluation of the importance of individual indicators for a generalized indicator of the ecological properties of a mobile power tool, according to the results of a survey of experts, showed that the most impact is the index of soil consolidation, then mechanical destruction of soil, composition of exhaust gases, pollution of operating fluids, noise, vibration and least impact is a layout diagram of the power tool. The analysis of these indicators allows us to determine which structural-technological or regime parameters of the energy source and to what extent influence the general indicator of its environmental properties. And the more deeply this analysis will be, the more accurate and successful will be proposed constructive-technological or regime measures to improve them.

KEY WORDS: TECHNOLOGICAL PROPERTIES; AN INDICATOR OF ECOLOGICAL PROPERTIES; ECOLOGICAL COMPATIBILITY; MOBILE ENERGY TOOL; METHOD OF RANKING INDICATORS.

1. Introduction

Methods of the theory of technological exploitation allow to carry out a quantitative assessment of the technological level of the mobile power tool, to determine the degree of conformity of its design parameters and technical characteristics, as well as technological properties to the general requirements of the technological process of agricultural production [1-4]. The method of evaluation of technological properties of mobile energy devices is proposed by d.n. Kutkov G.M. [1] takes into account the most important, aggregated indicators, such as technological universality, productivity, agrotechnical quality and cost of the performed operation, but does not take into account the index of their environmental properties.

It is clear that mobile energy means are one of the main sources of negative technogenic influence on the environment by harmful products of combustion of diesel fuel, leakage of operational lubricating and cooling liquids, mechanical sealing and soil destruction, acoustic influence, vibration, etc. That is why taking into account the generalized index of environmental properties in the methodology for assessing the technological level makes it possible to assess the conformity of this mobile energy source with the technological requirements from the standpoint of environmental safety throughout the complex of agricultural operations, for which it is intended to be used in the machine-tractor aggregates.

But to calculate the indicator of the technological level of the mobile power tool, in this case, it is possible after the weighting factors of each of the generalized indicators will be obtained. Therefore, research aimed at solving this issue is relevant.

2. Preconditions and means for resolving the problem

The method of calculation of the main generalized indicators of technological properties (technological universality, productivity, agrotechnical quality and cost of the performed operation) is sufficiently detailed in [1]. In contrast to the mentioned indicators, the evaluation of the generalized indicator of the environmental properties of a mobile power tool is not sufficiently studied today. In the classical theory of the operation of a machine-tractor park, the index of “environmental compatibility of a complex of machines” is determined by indicators of ecological compatibility: energy content, soil compaction, humus extraction, pollution of the environment [5].

However, in the thesis [6], for example, a more advanced new methodology for defining the generalized ”ecological safety factor” (Ge) is recommended from the influence of the work of the machine-tractor unit on the environment, which is represented in the form of a relative coefficient of deterioration of the sum of the ecological parameters of the work of the latter, attributed to their normative values:

\[ G_{EC} = \frac{K_{U1}}{U1} + K_{Fp} \cdot Fp + SK_{s} + K_{N} \cdot N/NI + K_{CO} \cdot CO/lco + K_{CH} \cdot CH/lch + K_{NO} \cdot NO/xno + K_{L1} \cdot L1/L1 + K_{L2} \cdot L2/L2 + K_{L3} \cdot L3/L3 + K_{N} \cdot N/NI + K_{CO} \cdot CO/lco + K_{CH} \cdot CH/lch + K_{NO} \cdot NO/xno + K_{L1} \cdot L1/L1 + K_{L2} \cdot L2/L2 + K_{L3} \cdot L3/L3 + K_{N} \cdot N/NI, \]

where \( K_{U1} \) – mechanical destruction of soil; \( K_{NI} \) – pollution by petroleum products; \( K_{Fp} \) – coefficient of influence from the pressure of the tractor's propulsion; \( K_{Ni} \) – dimming of exhaust gases; \( K_{CO} \) – carbon monoxide emissions; \( K_{CH} \) – emissions of hydrocarbons; \( K_{NO} \) – emissions of nitrogen oxides; \( K_{L1} \) – internal noise; \( K_{L2} \) – external noise; \( K_{L3} \) – vibration transmitted to the environment by the technical means; \( K_{TR} \) – the weight of technological waste MTA; \( U1 \) – control measures in accordance with mechanical destruction of soil, concentration of carbon emissions, hydrocarbons, nitrogen oxides, internal and external noise, vibration; \( F_{pc} \) – the specific pressure of the tractor's propulsion on the ground, respectively, during testing and recommended.
tors in accordance with technological and ecological factors: the qualifications of individual indicators of the environmental and technological properties of the mobile power tool (tables 1 and 2), the ranks of the indicators themselves were determined. Moreover, the highest rank corresponds to the indicators of the highest significance, the lowest, respectively, - the least significant.

**Table 1 - Results of expert polls on the significance of individual indicators of the environmental properties of a mobile energy means**

<table>
<thead>
<tr>
<th>Experts</th>
<th>( K_{\text{qeg}} )</th>
<th>( K_{\text{pol}} )</th>
<th>( K_{\text{nhd}} )</th>
<th>( K_{\text{n}} )</th>
<th>( K_{\varepsilon} )</th>
<th>( K_{\text{ks}} )</th>
<th>( K_{s0} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastukhov V.I., Prof.</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Didur V.A., Prof.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Nadykto V.T., Prof.</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Petrokh V.G., Prof.</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Uleksin V.O., PhD</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Kavachov V.P., PhD</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Fedinosko M.P., PhD</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Bogatyrrova O.B., PhD</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Shkarivsky G.V., PhD</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Petrokh V.R., PhD</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>sum of ranks ( T )</td>
<td>37</td>
<td>44</td>
<td>18</td>
<td>51</td>
<td>53</td>
<td>16</td>
<td>61</td>
</tr>
<tr>
<td>deviation from the average amount of ranks</td>
<td>9</td>
<td>16</td>
<td>-10</td>
<td>23</td>
<td>25</td>
<td>-12</td>
<td>33</td>
</tr>
<tr>
<td>square deviations</td>
<td>81</td>
<td>256</td>
<td>100</td>
<td>529</td>
<td>625</td>
<td>144</td>
<td>1089</td>
</tr>
<tr>
<td>Sum of squares deviations ( R )</td>
<td>2824</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2 - Results of expert polls on the significance of individual indicators of the technological properties of a mobile energy product**

<table>
<thead>
<tr>
<th>Experts</th>
<th>technological indicator</th>
<th>productivity indicator</th>
<th>agronomic properties indicator</th>
<th>the cost of the technological processes indicator</th>
<th>environmental indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastukhov V.I., Prof.</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Didur V.A., Prof.</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Nadykto V.T., Prof.</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Petrokh V.G., Prof.</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Uleksin V.O., PhD</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Kavachov V.P., PhD</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Fedinosko M.P., PhD</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Bogatyrrova O.B., PhD</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Shkarivsky G.V., PhD</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Petrokh V.R., PhD</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>sum of ranks ( T )</td>
<td>27</td>
<td>28</td>
<td>28</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>deviation from the average amount of ranks</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>square deviations</td>
<td>81</td>
<td>0</td>
<td>0</td>
<td>81</td>
<td>4</td>
</tr>
<tr>
<td>Sum of squares deviations ( R )</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The assessment of the consistency of the estimates obtained from experts was carried out using the coefficient of concordation $W$ [1].

The verification of the significance of the coefficient of concordation $W$ was carried out using the $\chi^2$-Pearson criterion [1].

According to the results of the expert survey (see Tab. 1 and 2), the weighting coefficients of the individual indicators of ecological and technological properties for mobile energy products were determined according to the equation [1]:

$$ S_i = \frac{1 - t_i - 1}{n} \sum_i (1 - \frac{t_i - 1}{n}) $$

where $t_i$ - the final rank of a single indicator of ecological and technological properties;

$n$ - total number of individual indicators.

Tab. 1 indicates that the generalized indicator of the environmental properties of a mobile energy facility is most strongly influenced by the $K_{mds}$ soil compaction index, then the mechanical destruction of the soil $K_{nds}$, the composition of the exhaust gases $K_{ep}$, the pollution of the operating liquids, the $K_{pol}$ noise $K_{n}$, the vibration of the $K_v$, and the smallest effect - the layout scheme of the energy $K_{ns}$. Analysis of these indicators allows us to determine which structural-technological or regime parameters of the energy resource and to what extent affect the generalized index of its environmental properties. And the more deeply this analysis will be, the most accurate and successful will be proposed constructive-technological or regime measures to improve them.

The indicator of the environmental properties of a mobile power tool by the formula (3) as a result of a survey of experts (Tab. 1) will take the form:

$$ E_{ont}=0,25 K_{vs} + 0,22 K_{mds} + 0,18 K_{ep} + 0,14 K_{pol} + 0,11 K_{ns} + 0,07 K_{v} + 0,03 K_{ep} $$

According to experts, the greatest importance is the index of technological universality of $U_T$, then the agrotechnical properties of $A_T$, the productivity of $W_T$, the environmental integrity of the $E_T$ and the smallest impact is the cost index of the technological process $C_T$. And the equation for calculating the technological level of the mobile power tool by the formula (1) as a result of the expert survey (Tab. 2) will take the form:

$$ P_t = 0.33U_T + 0.27A_T + 0.2W_T + 0.13E_T + 0.07 C_T $$

The obtained result shows that today it is more relevant to assess the technogenic impact of a mobile energy facility on the environment than the cost of its implementation unit of work. And with this conclusion, one can not disagree, since the neglect of the impact on the environment in the near future can nullify the economic profit from the production of agricultural products. Therefore, estimation of the technological properties of a mobile power tool according to the criteria of its technological universality, productivity, agrotechnical quality, environmental properties and the cost of the performed operation allows us to make the most objective decision as to the feasibility of introducing it into production, the efficiency of its use and the technological level of any technological process.

4. Conclusions

1. The actuality and significance of the influence of the environmental properties of mobile energy on its technological properties is confirmed by a psychological experiment through a survey of experts. It is established that the value of this property, according to experts, is less than technological universality, productivity, agrotechnical quality, but higher than the cost of the performed operation. Taking into account the index of the environmental properties of a mobile power tool allows us to make the most objective decision as to the feasibility of introducing it into production, the efficiency of its use and the technological level of any technological process.

2. The evaluation of the importance of individual indicators for a generalized indicator of the ecological properties of a mobile power tool, according to the results of a survey of experts, showed that the most impact is the indicator of soil consolidation, then mechanical destruction of soil, composition of exhaust gases, pollution of operating fluids, noise, vibration and least impact is a layout diagram of the power tool. The analysis of these indicators allows us to determine which structural-technological or regime parameters of the energy source and to what extent influence the general indicator of its environmental properties. And the more deeply this analysis will be, the most accurate and successful will be proposed constructive-technological or regime measures to improve them.

5. References


IDENTIFICATION OF SPATIAL VARIABILITY OF SOIL PHYSICO-CHEMICAL PROPERTIES FOR PRECISION FARMING

Lukas V., Neudert L., Novák J., Paulová N.
Department of Agrosystems and Bioclimatology, Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic
vojtech.lukas@mendelu.cz

Abstract: Site-specific crop management practices, known as precision farming, require information about detailed spatial distribution of soil physico-chemical properties related to the yield productivity. Traditional mapping of soil properties in form of soil sampling is inefficient for assessment of high level of spatial variability due to the high costs. For this reason, a study was conducted within the research projects NAZV Q1610289 and TACR TH2030113 to evaluate the digital soil mapping techniques, including proximal sensing methods in the form of on-the-go measurement of soil conductivity, for mapping of agronomical relevant soil properties. The experimental work was carried out on the selected fields of Rostenice a.s. farm enterprise, located in the South Moravia region of Czech Republic. Total area of 475 ha within eight fields was measured from 2013 to 2016 by using CMD-1 instrument (GF Instruments, Czech Republic) mounted on the plastic sledges. This device measures the electrical conductivity by the principle of electromagnetic induction (EMI) with 0.98 m dipole center distance and effective depth of measurement of 1.5 m (vertical mode) or 0.75 m (horizontal). Soil properties were obtained by soil sampling in irregular grid with the density of 1 sample per 3 ha. Soil samples were taken from the depth of 30 cm and analyzed for soil texture (percentage of clay, silt and sand particles), content of available nutrients (P, K, Mg, Ca), cation exchange capacity (CEC), soil organic matter content (SOM) and wilting point (WP). The results showed different level of spatial variability among the observed fields. The correlation analysis proved differences in main sensitivity of EMI to the soil properties, mainly the percentage of clay particles smaller than 0.002 mm (r = 0.598). The correlation between EMI and nutrients content in soil and pH value was significant only for few fields. These outcomes showed, that rather than predictor of soil properties could be on-the-go measurement of soil EC used for identification of main zones within the fields at high spatial level.

Keywords: SOIL HETEROGENEITY, DIGITAL SOIL MAPPING, SOIL PROPERTIES, ELECTROMAGNETIC INDUCTION.

1. Introduction

The Czech Republic has a specific land use defined by the highest average farm holding area in the European Union (over 130 ha per farm). The national statistical evaluation of agriculture sector (Ministry of Agriculture of the Czech Republic, 2015) showed that 50.3 % of agricultural land in Czech Republic is managed by farm enterprises with acreage 1000 ha. Also, there is known large average size of fields - statistical evaluation of the size of land parcels shows that 60 % of arable land is located within the fields with the area over 20 hectares. Higher diversity of the landscape relief and pedoclimatic conditions in combination with the size of land blocks occur in visible heterogeneity of land. This leads to an increased interest in the precision farming practices and technologies for site-specific crop management, where high quality of input geo-information about the land are required.

One of the method for digital soil mapping is measurement of apparent soil electrical conductivity (EC), which is used for the assessment of soil heterogeneity since the late 1970s (Doolittle and Brevik, 2014). In the beginning, it was applied for identification of soil salinity, later became a method for mapping of soil variability in site specific crop management (Corwin and Lesch, 2005a).

The measurement of soil electrical conductivity is a cost-effective method complementing traditional soil survey, which provides rapid and non-invasive information on soil texture variability and available soil moisture (Godwin and Miller, 2003). According to the study of Corwin and Lesch (2005a), the most important factors influencing EC include the content of soluble salts in soil solution, relative moisture, soil water content and bulk density. The effect of these factors can be found in most of the studies cited here, but their significance varies with regard to specific site conditions. In agricultural areas where soil salinization is not a significant factor, EC measurements are the primary function of soil moisture and soil texture (Godwin and Miller, 2003). Finding the dominant soil characteristics on each plot is necessary for correct interpretation of EC maps (Corwin and Lesch, 2003; Brevik et al., 2006). In addition, the knowledge of the most important factors influencing the spatial variability of crop yield or production quality is required for utilization of EC in site specific crop management (Corwin and Lesch, 2005b).

The advantage of the EC measurement is the vertical penetration of the electromagnetic or electric signal by the soil, and thus obtaining information of the soil profile. The result of the EC measurement is also not affected by the vegetation cover of the soil or crop residues (Brevik et al., 2003), which makes it possible to carried out measurement on bare soil or under vegetation cover.

The aim of this study was to verify the use of on-the-go soil EC measurement by electromagnetic induction for mapping of within field spatial variability of selected physico-chemical properties of soil.

2. Material and Methods

The study was carried out on the selected fields of farm enterprise Rostenice a.s., located in the South Moravia region of Czech Republic (49° 05’ N, 16° 50’ E). Experimental fields are listed in Table 1, total area covered by this study was 476 ha of arable land. Predominant soil type within the fields was identified from available soil maps as Chernozem, Cambisol, haplic Luvisol and occasionally also Calico Leptosols.

Fig. 1 Soil sampling by automatic sampler Nietfeld Duprob 60.

Soil sampling

Soil properties were obtained by soil sampling in irregular grid with the density of 1 sample per 3 ha. More dense sampling grid (2 samples per ha) was applied for field with ID 5601/4 (acreage 37.79 ha). Soil samples were taken from the depth of 30 cm by using Duoprob 60 automatic sampler (Nietfeld, Germany) drawn by off-rad vehicle (Fig. 1). The position of each sampling point was localized with Trimble Pathfinder ProXH DGPS reaching submeter accuracy. Each sample is composed from 5 sampling cores taken in the perimeter of 15-20 m. Soil samples were analyzed in laboratory for soil pH value, content of available nutrients (P, K, Mg, Ca), and soil organic matter content (SOM). Also percentage of clay (soil particles < 0.002 mm), silt (0.002 – 0.05) and sand (>0.25 mm) were estimated.

Table 1. Total area covered by this study was 476 ha of arable land. Predominant soil type within the fields was identified from available soil maps as Chernozem, Cambisol, haplic Luvisol and occasionally also Calico Leptosols.
Mapping of soil electrical conductivity

On-the-go measurement of soil EC was carried out by using CMD-1 instrument (GF Instruments, Czech Republic) in 2013 (117 ha) and 2016 (334 ha), both in the period without crop cover of soil. This device measures the electrical conductivity by the principle of electromagnetic induction (EMI) with 0.98 m dipole center distance and effective depth of measurement of 1.5 m (vertical mode) or 0.75 m (horizontal). The instrument was mounted on the plastic sledge in horizontal mode and drawn by off-road vehicle (Fig. 2) in 20 - 25 m track-lines. Measured values were recorded in 1 – 2 sec intervals together with geolocation by Trimble CFX 750 DGPS with submeter accuracy and later processed by ESRI ArcGIS software. As the output dataset, raster layer with spatial resolution of 5 m per pixel was created by using spatial interpolation (ordinary kriging). The measurement in 2016 was extended by six-dipole experimental instrument CMD-6L for simultaneous measurement in six soil depths in horizontal mode over next 268 ha. For this study, only the layer corresponding by the depth with CMD-1 was analyzed.

![Fig. 2 Measurement of soil EC by GF Instruments CMD devices.](image)

3. Results and Discussion

The basic information about observed fields and overview of experimental activities are written in Table 1. Besides the general information about the recorded EC values, also year of the measurement, used instruments and statistical characteristics of EC for individual fields are reported. Different ranges of EC values across the fields may, in addition to various soil conditions, also correspond to different measurement periods (spring / autumn) and thus also to different soil moisture levels during the measurement. However, recent studies have shown that results of repeated measurements under different moisture vary, but the spatial distribution within the field does not change significantly (Serrano et al., 2013; Lukas et al., 2009).

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Area [ha]</th>
<th>EC Avg.</th>
<th>EC Min.</th>
<th>EC Max.</th>
<th>EC CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2401/10</td>
<td>70.79</td>
<td>75.32</td>
<td>40.35</td>
<td>131.74</td>
<td>18.82</td>
</tr>
<tr>
<td>2401/12</td>
<td>46.05</td>
<td>53.17</td>
<td>27.74</td>
<td>97.00</td>
<td>21.69</td>
</tr>
<tr>
<td>2301/15</td>
<td>65.82</td>
<td>49.65</td>
<td>26.01</td>
<td>117.62</td>
<td>30.14</td>
</tr>
<tr>
<td>2016 - GF Instruments CMD1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2401/9a</td>
<td>96.08</td>
<td>68.45</td>
<td>32.12</td>
<td>130.58</td>
<td>13.67</td>
</tr>
<tr>
<td>5601/4</td>
<td>37.79</td>
<td>46.36</td>
<td>15.99</td>
<td>111.69</td>
<td>34.41</td>
</tr>
<tr>
<td>2401/9b</td>
<td>62.87</td>
<td>25.28</td>
<td>10.56</td>
<td>94.30</td>
<td>19.99</td>
</tr>
<tr>
<td>3411</td>
<td>34.49</td>
<td>45.02</td>
<td>21.88</td>
<td>107.56</td>
<td>30.19</td>
</tr>
<tr>
<td>5301/4</td>
<td>62.34</td>
<td>32.24</td>
<td>19.06</td>
<td>60.13</td>
<td>15.38</td>
</tr>
</tbody>
</table>

The variability of the EC measured values, evaluated by the coefficient of variability (CV), ranged from 13.67 to 34.41 %. Resulted maps of EC values are illustrated in Figure 3. Generally, the lowest variability was observed at soil pH, on the contrary, the highest of Mg content in soil. Between each plot, the CV varies significantly depending on soil characteristics. Values of coefficient of variability varied among fields based on the soil characteristics.

![Fig. 3 Maps of soil EC after classification. Black crosses represent soil sampling locations.](image)
Table 2: Pearson correlation coefficients among soil sampling results and soil electrical conductivity. Bolded values are statistically significant at the level of 95% probability.

<table>
<thead>
<tr>
<th>EC</th>
<th>pH</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
<th>SOM</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>2301/15</td>
<td>0.237</td>
<td>0.228</td>
<td>0.028</td>
<td>0.205</td>
<td>-0.213</td>
<td>-0.166</td>
<td>0.334</td>
</tr>
<tr>
<td>2401/10</td>
<td>-0.243</td>
<td>0.134</td>
<td>0.691</td>
<td>0.562</td>
<td>0.113</td>
<td>0.144</td>
<td>0.473</td>
</tr>
<tr>
<td>2401/12</td>
<td>-0.208</td>
<td>-0.092</td>
<td>0.295</td>
<td>-0.032</td>
<td>-0.260</td>
<td>0.356</td>
<td>0.545</td>
</tr>
<tr>
<td>2401/9a</td>
<td>0.188</td>
<td>-0.111</td>
<td>-0.099</td>
<td>-0.155</td>
<td>0.060</td>
<td>0.021</td>
<td>0.348</td>
</tr>
<tr>
<td>2401/9b</td>
<td>0.135</td>
<td>0.331</td>
<td>0.319</td>
<td>0.326</td>
<td>0.460</td>
<td>0.333</td>
<td>0.598</td>
</tr>
<tr>
<td>3411</td>
<td>-0.189</td>
<td>-0.282</td>
<td>0.166</td>
<td>0.633</td>
<td>0.313</td>
<td>0.076</td>
<td>0.542</td>
</tr>
<tr>
<td>530/1/4</td>
<td>-0.245</td>
<td>0.270</td>
<td>0.605</td>
<td>-0.309</td>
<td>-0.483</td>
<td>-0.293</td>
<td>0.107</td>
</tr>
<tr>
<td>560/1/4</td>
<td>0.202</td>
<td>0.296</td>
<td>0.261</td>
<td>0.213</td>
<td>-0.069</td>
<td>0.589</td>
<td>0.568</td>
</tr>
</tbody>
</table>

Considering different EC measurement dates, the assessment of the relationship with soil properties should be done individually for each plot separately. The correlation between all soil samples and EC was significant only for clay content (r = 0.265), silt (r = 0.194) and sand (r = 0.336). Although it is possible to build a robust model for prediction of soil properties, as shown by Heil and Schmidhalter (2012) in predicting soil texture from EC combined with elevation and terrain aspects, most studies expect the greatest potential of spatial EC measurement in precision agriculture for delineation of management zones and directed soil sampling (Corwin and Plant, 2005; Doolittle and Brevik, 2014; Peralta and Costa, 2013; Moral et al., 2010). Directed (or zone) soil sampling based on EC mapping leads to a significant reduction in the number of samples compared to sampling in a regular network (Lesch, 2005). At the same time, the data of EC can be used as ancillary data to subsequently refine soil mapping from low density sampling by spatial interpolation techniques (Kerry and Oliver, 2003).

4. Conclusions

The results of correlation analysis showed main sensitivity of EC measurement to the soil texture categories (content of clay particles) and content of SOM. Except of K content, the relationship between EC and nutrients content in soil and pH value was almost not significant. The main advantageous of EMI measurement is the spatial differences in soil properties. Recent studies showed that these zones can be used for directed soil sampling or to estimate the management zones for site specific crop management.

Acknowledgement

This study was supported by research projects NAZV QJ1610289 “Efficient use of soil productivity by site specific crop management” and TACR-EPSILON TH02030133 “Agriculture management system integrating efficient nutrients utilization by crops and water conservation against non-point source pollution”.

References


IDENTIFYING THE PHYSICAL PROPERTIES OF THE SOIL USING PROPER SOIL SOFTWARE

Assoc. Prof. Mitev G. DSc., Asst. Prof. Kalinova S, PhD., Asst. Prof. Bratoev K.PhD.
University of Ruse "Angel Kanchev", Bulgaria
gmitev@uni-ruse.bg, skalinova@uni-ruse.bg, kbratoev@uni-ruse.bg

Abstract: The main physical soil properties are considered highly important for soil fertility. Measuring only 4 indicators taken from the soil samples and by using physical equations can determine valuable results for the soil physical properties. To facilitate the analysis a develop software could help.

KEYWORDS: SOIL PHYSICAL PROPERTIES, SOFTWARE PRODUCT

1. Introduction
Purpose and environment for development
The physical properties of the soil can be identified in several ways. In this case, we carry out the identification of the whole range of physical properties by introducing four indexes – container volume, wet soil mass, dry soil mass and volume of the hard soil.

The application has been designed for:
- Registering the farmers and their fields, which they committed for the research trials;
- Identifying the physical properties of the soil at different depths;
- The graphic presentation of the data after processing the input data;
- Creating a database.

Environment for developing the application
The application has been developed on Microsoft Access 2010. Visual Basic For Application (VBA) was the language used for developing the forms and references.

2. General information
Working with the application we use:
Forms – the forms are used to support up-to-date information in the database. They provide opportunity to enter, change or delete records in the tables. For each form, where necessary, drop-down menus have been created for selecting the allowed values. When wrong data have been entered, a message is visualised in a window, showing where and why the error has occurred, and an opportunity is provided for making a change.
Graphs – graphic presentation of set and/or calculated data.
References – using references, the information stored in one or more tables in the database can be viewed and printed.
User guide
Main form of the application

The main form of the application is visualised immediately after a PropeSoil.accdb file is opened (fig.1). Using the control buttons, different execution actions can be selected such as forms for supporting the information in the tables, references and graphs based on the data stored, or creating a pdf file. For some of the forms there are extra buttons for choice of action, so as to facilitate the work of the user.

When the Escape button is pressed, the application stops working and MS Access is closed.

For easier use of the application, the actions executed are organised by themes. Choosing any of the buttons, a form is activated within the main form, which contains buttons for executing specific actions (forms or reports). Through each of the forms, the records saved in the tables can be added, erased or changed by pressing control buttons.

Data input (fig.2)
For each form, the following rules have been applied for data input:

- Each of the number fields is checked and an error message is displayed when a field is incorrect;
- There is a command button “Help”, which indicates the way to fill in the fields and the restrictions that have been set for them;
- For some of the fields there are drop-down menus of values for selection by user;
- Command buttons for adding, saving, deleting, as well as viewing and printing;
- Command buttons for reviewing and searching for records;
- Command buttons for escape from the respective form.

Farmers and arable fields (fig.3) – first, the user assigns in the left-hand sub-tab a farmer’s name and the number of fields this farmer cultivates while in the right one - the name of the field and the size of the areas. The software assigns a code to the farmer.

Viewing and printing (fig.4) – the user sets a mandatory date (a calendar is selected by positioning the cursor on the field “Date of printing”) and he can choose what data to print and view:

- Comprehensive list – the data of all registered farmers, whether they have fields assigned for cultivation or not, are displayed;
- List of all farmers with data input – only the data of those registered farmers, who have areas for cultivation assigned;
- A single farmer –the name of the farmer is selected from a drop-down menu.
Identifying the physical properties of the soil (fig. 5) – the name of a farmer and the number/name of a field are selected from drop-down menus of values, then the sequence number of the trial is set for the respective field of the farmer (no double numbers for the trial in the respective field are allowed) and the date (selected from a calendar to the right of the tab). Data on the depths measured are entered only in the first four fields (they can be set for only some or for all depths). When the values are set and the button “Calculate and save” is selected, the values are calculated by the software, using predefined formulas.

The command buttons in the section “Review all records and search” are used for reviewing all the records or searching.

Working with the equipment:
The equipment needed for the field measuring is:
- Metal container with openings on both sides and plastic caps; hammer; wooden bar, spade and knife.

A vertical walled trench is excavated at a certain depth. The depth is measured and recorded. The metal container is put on the wall and with the help of the wooden bar and the hammer is driven into the soil. The soil on both sides of the container is flattened and the plastic caps are placed.

The volume of the container is measured and recorded. Since it is a constant value, it is measured only once.

The mass of the container, filled with wet soil, is measured and recorded. The metal container is placed into a dryer and the soil is dried. The mass of the dried soil is measured and recorded.

One of the caps is placed and water is poured into the container until all the pores are filled. The volume of the water absorbed by the soil is measured and then subtracted from the total volume of the container. The difference shows the volume of the hard soil. If the soil is well-structured, the hard particles are about 50%. The data measured are filled in the table – fig. 1 (the text in red). Then you click on the button “Calculate and save” and the physical properties of the soil are automatically determined.

<table>
<thead>
<tr>
<th>Фермери и техните обработваеми полета</th>
</tr>
</thead>
<tbody>
<tr>
<td>Име на фермер</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Петър Борисов</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Обща обработваема площ 898,00

Fig. 4. Viewing and printing

Fig. 5. Table with data input and results obtained
When you click on “View and print” (fig.6), a form comes out to determine whether a list of all information saved should be made, or only one for the calculations made for a single farmer. The user should enter a mandatory date of the viewing and printing (fig.7).
After determining the physical properties of the soil, the user can present the indexes calculated for the trials registered at different depths in a graph (fig.8). This can be done by selecting the command button „Graphic generation” from the main form of the application. A form is selected and from drop-down menus for the name of the farmer and number of soil layer (they are mandatory) it is determined which of the indexes will be shown as a graph (you can do it for one index only). Two versions are possible:

- „Viewing with data” (fig.9) – generating of a graph and the data used for its generation. All data on the registered trials can be viewed by scrolling.
- „Graph only” (fig.10) – only the graph can be viewed without the data, and it can also be printed by pressing the “Print” button. At the top of every column the respective values calculated by the software are displayed.

Fig.8. Graphic presentation of indexes
Fig. 9. Graphs with data

Fig. 10. Graphs only
For each of the registered farmers and calculations made for the physical properties of the soil in his arable land a pdf file can be generated (fig. 11). After the name of the farmer is selected from a drop-down menu, the file is named (you can also determine where it should be saved – directory and subdirectory), the date of generation is set, you click on the command button „Generate a pdf file”, and the newly generated file is opened for viewing in Adobe Reader.

3. References:


2. Ангелов, Е., Д. Илков, Г. Димитров, И. Ватралов, К. Енков, Проучване на почвите в България, Ки. 2, Разградски, Русенски и Силистренски окръг, София, 1975, Издателство на БАН.


7. Панов, И. М., В. И. Ветохин. Физические основы механизки почв, Киев, Феникс, 2008.


ACTUALITY OF THE PROBLEM OF WATER DEPURATION OF THE DNIEPER ACCORDING TO THE THEORY OF SOCIAL WELFARE

Prof. D. Skrypnyk A., PhD Stud. Holiachuk O.
National University of Life and Environmental Sciences of Ukraine – Kyiv, Ukraine
E-mail: avskripnik@ukr.net, olha.holiachuk@gmail.com

Abstract. In this article we wish to evaluate efficiency of use of Dnieper cascade hydropower plants on the basis of common approaches to environmental management. We evaluate the efficiency of use the flooded areas of the hydropower station in agriculture. Dnieper reservoirs ranking on the degree of energy risk (the possibility of man-made tsunami generation) was made. There are some water depuration problem mentioned and ways to solve problem of water depuration in Dnieper river.

KEYWORDS: WATER DEPURATION, HYDROPOWER PLANTS, RENEABLE ENERGETIC, SOCIAL WELFARE

1. Introduction
Before the era of nuclear power, contribution of hydropower in the energy balance of the former Soviet Union was considered indisputable. Thus the negative effects associated with the creation of reservoirs on the plains were not taken into account e.g. flooding of large areas, destruction of towns and historic monuments, increase of the risk of man-made disasters. But time passed and in 1970s in Ukraine were built several nuclear power plants and as a result appeared the need to develop solar, wind and bioenergy and it led to decrease of the share of electricity generation by hydropower plants to 5-7%. Over the past decade, the agricultural sector of the Ukrainian economy has become one of the major players in the global food market and agricultural export of the country has become one of the landmarks of the national economic development. That is why there is an urgent need to use territory of the cascade of Dnieper reservoirs for agricultural purpose. However, beside inappropriate use of land resources [1] and deterioration of the quality of water resources there is a high risk of man-made disasters which can be caused by the functioning of the Dnieper cascade hydropower plants.

2. Prerequisites and means for solving the problem
Ukrainian scientist made research that showed high efficiency (99,9%) of water purification from cationic and direct dyes under the certain pH by tubular ceramic membranes modified by hydrocomplexes Fe^{3+}. Found that the pH changing of the solutions affects the scientific productivity of these membranes [2].

The main task of these studies was the identification and analysis of existing methods and wastewater treatment schemes for landfills, with the purpose of creating an information base for the development of technologies and equipment sewage treatment. High content of toxic components in drains, incl. ions of heavy metals (sewage composition water is given in our work [1]), does not allow to clean sewage in urban treatment plants.

A number of recommended technological schemes that combine biological cleaning with other traditional methods purification of wastewater from solid waste landfills. For the purification of drainage waters of polygons The method of biocleaning with aerobic and anaerobic reactors. Previously drainage water is rendered harmless on combined technology: flocculation and coagulation with lime milk Ca (OH)\textsubscript{2} sediment settling and filtration; subsequent blowing of ammonium nitrogen in cooling towers; treatment filtrate by ultraviolet rays and the final filtration. After biological purification at the last stage is expected sorption aftertreatment on granular activated coal and carbon fiber materials. However, even such a comprehensive cleaning does not allow reduce the content of toxic impurities to normative indicators. For these purposes, dilute purified runoff surface waters [3].

3. Solution of the examined problem
The problem of water pollution is directly caused by significant masses of stagnant water of the Dnieper. This also directly affects the generation of electricity by cascade power plants. In our view, reducing hydropower volumes is not a random factor, but rather a factor that can be explained by the wear of equipment for power plants that has been operating for a long period of time. Therefore, without proper upgrading of power plants and associated infra structure (gateways, dams of reservoirs), hydroelectricity production will decrease. At the same time, the risks of technogenic disasters continue to increase as a result of the further exploitation of the Dniprovsksky hydroelectric power station. At the same time, the efficiency of renewable energy is increasing. In the first place, the advantages of the energy industry should include a small negative impact on the state of the environment: for example, in Ukraine there are significant areas of unproductive and untreated land where solar enrichment is possible. With regard to the use of wind energy, due to the small areas that are withdrawn from agrarian use, negative external effects, as the European experience shows, are associated with the possibility of an obstacle to seasonal migration of birds. Therefore, this factor must be taken into account when choosing places for rising wind turbines.[3]

\begin{table}
\centering
\begin{tabular}{|l|c|c|c|c|c|}
\hline
 & A (initial value) & \(\alpha\) (growth rate) & \(t_0\) (start research) & \(R^2\) (determination coefficient) & \(F\) (Fischer Criterion) & \(\delta\) (standard error) \\
\hline
Hydro & 11,738 & -0,008 & 2002 & 0,44 & 12,18 & 0,502 \\
Renewable & 0,0377 & 0,3338 & 2002 & 0,56 & 13,34 & 0,018 \\
\hline
\end{tabular}
\end{table}
In recent years, significant growth rates of growth have been observed in Ukraine due to renewed sources. Represent the trends observed in hydropower and renewable energy in the form of exponential trends (Table 1):

\[ w(t) = A e^{a(t-t_0)} \]

On the basis of the observation interval (2002-2015 years), the trend was to reduce the generation of electricity at the expense of the hydroelectric power station with a relative speed of 0.8% per year and an increase by 23.4% per annum in the energy sector. Both coefficients are significant (the significance level is less than 5%, that is, the zero hypothesis about the absence of stable tendencies can be rejected). Assuming that these trends will continue in the future (in favor of this hypothesis is evidenced by the development of world energy), then the forecast period of time for the possibility of changing hydropower on the renewed 2024-2027 years (Fig. 1).

Let's turn to the question of assessing the effectiveness of the existing cascade of the Dnieper hydroelectric power stations from the standpoint of public welfare. In the previous work, the alternative efficiency of the flooded areas of reservoirs was evaluated in comparison with their use in the agrarian business. It has been shown that only for the Dnieper Hydropower Plant alternative cost of agricultural products from flooded areas does not exceed the cost of generated electricity. For other reservoirs, the cost of generated electricity is exceeded at times. Let us dwell on another convincing comparison of the efficiency of electricity generation (Table 2).

It should be emphasized that from the further use of reservoirs the greatest losses are, of course, the agrarian sector. However, losses from irrational use of flooded areas are not the only ones that bear the agrarian sector as other sectors of the Ukrainian economy from the prolongation of the operation of the cascade of Dneprovskih HPP [6,7].

4. Results and discussion

All possible losses connected with functioning of reservoirs are not limited to the wastage of flooded areas. The general scheme of the risks evaluation of further functioning of reservoirs is presented in Figure 2. They can be divided into three groups: economic, technological and environmental.

We made an attempt to assess the expected total annual losses \( \bar{L} \) which consist of economical - \( L_{ek} \); ecological - \( L_{ekol} \); and technological - \( L_t \):

\[ \bar{L} = L_{ek} + L_{ekol} + L_t \] (1)

In the first approximation economic losses are equal to the difference between the price of potential agricultural products \( V_{ap} \) and the value of producing electric energy \( V_e \):

\[ L_{ek} = V_{ap} - V_e \] (2)

Environmental risk in a first approximation must be evaluated on the basis of cost of measures aimed to bring the mass of water in the reservoir (with absence of flow) to state of the river water [4,5,8].
5. Conclusion

We propose a complex approach to risk assessment of use of the Dnieper cascade hydropower station. We use a stochastic method of assessment of potential losses connected with the use of Dnieper reservoirs in order to assess the losses, which can be caused by violation of the integrity of the dam. We evaluated the potential losses of man-made tsunami for Kyiv reservoir. In the research was made evaluation of the potential hazards of each of the Dnieper reservoirs which can be caused by man-made tsunami. On the basis of the achieved results we ranked the reservoirs according to the degree of economic insecurit

Table 2 The efficiency of the most powerful hydroelectric power stations in the world compared to the Ukrainian hydroelectric plants

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>River</th>
<th>Installed capacity GW</th>
<th>Average annual production of billions of kWh/year</th>
<th>Area, sq. km</th>
<th>Efficiency, million kWh/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xiluodu (2014)</td>
<td>China</td>
<td>Yangtze</td>
<td>13.9</td>
<td>64.8</td>
<td>108</td>
<td>600</td>
</tr>
<tr>
<td>Dam of the leader of Joseph (1979)</td>
<td>USA</td>
<td>Colombia</td>
<td>2.6</td>
<td>12.5</td>
<td>34</td>
<td>367.65</td>
</tr>
<tr>
<td>Three Gorges (2012)</td>
<td>China</td>
<td>Yangtze</td>
<td>22.5</td>
<td>98.1</td>
<td>632</td>
<td>155.22</td>
</tr>
<tr>
<td>Grand Culli (1985)</td>
<td>USA</td>
<td>Colombia</td>
<td>6.8</td>
<td>20.0</td>
<td>324</td>
<td>61.73</td>
</tr>
<tr>
<td>Sayano-Shushenskaya (1989)</td>
<td>Russia</td>
<td>Yenisei</td>
<td>6.4</td>
<td>24.0</td>
<td>621</td>
<td>38.65</td>
</tr>
<tr>
<td>Dnieper (1947)</td>
<td>Ukraine</td>
<td>Dnieper</td>
<td>1.6</td>
<td>4.0</td>
<td>410</td>
<td>9.78</td>
</tr>
<tr>
<td>Robert-Bourassa</td>
<td>Canada</td>
<td>La Grand</td>
<td>5.6</td>
<td>26.5</td>
<td>2835</td>
<td>9.35</td>
</tr>
<tr>
<td>Churchill Falls</td>
<td>Canada</td>
<td>Churchill</td>
<td>5.4</td>
<td>35.0</td>
<td>6988</td>
<td>5.01</td>
</tr>
<tr>
<td>Middle-Dnieper (1964)</td>
<td>Ukraine</td>
<td>Dnieper</td>
<td>0.4</td>
<td>1.3</td>
<td>567</td>
<td>2.34</td>
</tr>
<tr>
<td>Kaniv (1972)</td>
<td>Ukraine</td>
<td>Dnieper</td>
<td>0.4</td>
<td>1.0</td>
<td>581</td>
<td>1.67</td>
</tr>
<tr>
<td>Kyiv (1964)</td>
<td>Ukraine</td>
<td>Dnieper</td>
<td>0.4</td>
<td>0.7</td>
<td>922</td>
<td>0.74</td>
</tr>
<tr>
<td>Kakhovka (1955)</td>
<td>Ukraine</td>
<td>Dnieper</td>
<td>0.4</td>
<td>1.5</td>
<td>2155</td>
<td>0.69</td>
</tr>
<tr>
<td>Kremenchuk (1959)</td>
<td>Ukraine</td>
<td>Dnieper</td>
<td>0.6</td>
<td>1.5</td>
<td>2252</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Transformation of the of the key symbol of the Ukrainian state of rapid flow into the system of stagnated reservoirs has no economic reasons taking into account that hydropower stations produce only 5% of the electricity of the total amount and the flooded areas can be used more efficiently, are more effectively use the flooded areas.
6. Literature:


**THE INFLUENCE OF SOIL MICROELEMENTS ON SULPHUR CONTENT IN THE SPRING WHEAT**

Dr. Brazienė Z. 1, Dr. L. Aleknavičienė2
Rumokai Experimental Station, Lithuanian Research Centre for Agriculture and Forestry1, UAB “Agrodema”2, Lithuania

E-mail: zitamo421@gmail.com, loreta@agrodema.lt

**Abstract:** The aim of this research was to identify the impact of soil microelements on sulphur absorption in the spring wheat. The field experiment was conducted in 2011-2015 at the Rumokai Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry on a Bathinhogley-Calc(aric) Lavisol (LVk-gld-w) with predominant silt loam on clay loam. During the years of research, the sulphur content in leaves and straw was positively influenced by these soil microelements: manganese (correlation coefficients of 0.973**, 0.989**, and 0.959**, respectively), molybdenum (correlation coefficients of 0.977**, 0.955**, and 0.929**, respectively) and zinc (correlation coefficients of 0.794**, 0.847**, 0.840**, respectively). Larger boron quantity in the soil reduced the sulphur content in the leaves of wheat (correlation coefficients -0.739**, -0.771**, -0.781**). The impact of soil microelements on sulphur content in the grains of spring wheat was not identified in this research. The sulphur content in the grains was strongly influenced by precipitation in June and July months.

**KEY WORDS:** SOIL MICROELEMENTS, SPRING WHEAT, SULPHUR CONTENT

1. Introduction

Although summer wheat is not very demanding to sulphur, but in recent years, its deficiency is rather noticeable in Western Europe. With shortage of sulphur, lower yields and lower quality wheat is produced. Sulphur is part of the protein's structural elements, therefore, its deficiency it can cause disruption in the growth and development of plants and slow down protein synthesis (Camberato, Casteel, 2017). Sulphur reduces the losses of nitrogen as it increases its absorption from the soil and improves its use in plants (Mašauskas and Mašauskiene, 2005). A big number of researchers describes good results of this chemical in cereals (Olfs et al., 2012, Staugaitiene et al. 2013, Staugaitis et all., 2014; Hayat et all., 2015). In order for the plants to make the most efficient use of sulphur in the soil, it is necessary to find out what factors can influence its assimilation. One such factor is the level of other nutrients in the soil.

The most common chemical elements in the environment are often found not isolated, but in combinations with other elements. Studies have shown that the presence of a single trace element or macronutrient affects the release of some other into the plant (An et al., 2004). There may be different types of interactions between different trace elements. Synergism occurs when the combined effect of the two elements is stronger than the sum of individual effects. Antagonism is observed when the combined effect is less than the sum of individual elements (Šlapakauskas, 2006).

The aim of this study is to find out the effect of soil micro-nutrients for the absorption of sulphur in spring wheat plants.

2. Objects and methods

The field experiment was conducted in 2011-2015 at the Rumokai Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry. A spring wheat cultivar ‘Triso’ was grown, the seed rate was 4.0-4.5 million ha\(^{-1}\). The sowing was carried out on 10-26 April. Preceding crop – sugar beets. Spring wheat was harvested on 14-24 August. Spring wheat was grown according to intensive technology, N150P52K105 fertilisers were applied before crop sowing. Soil was Bathinhogley-Calc(aric) Lavisol (LVk-gld-w) with predominant silt loam on clay loam. The top of the carbonate horizon and the gleicytice traceries were determined at the 60 cm depth. The pH value in the arable soil layer ranged from 6.4 to 7.4. Soil pH was determined in 1 N KCl extraction using a potentiometric method. The content of plant-available P\(_2\)O\(_5\) at the 0-20 cm layer was 239.0-388.0 mg kg\(^{-1}\) and the content of plant-available K\(_2\)O was 183.0-272.0 mg kg\(^{-1}\). The content P\(_2\)O\(_5\) and K\(_2\)O was determined using Egner-Riehm-Domingo (A-L) method.

Meteorological conditions. The precipitation in 2011–2015 during the growing season for spring wheat was distributed very unevenly, and the average daily temperature was higher than in the periods of 1981–2010. In 2011, dry periods prevailed during the spring wheat germination; therefore, the crop germination was extended and uneven. The temperatures during the tillering stage were favourable, and the plants formed the optimal crop density, but at the beginning of milky maturity and during harvesting the ears formed smaller grains because of significant precipitation. Favourable weather for spring wheat germination and tillering prevailed in the beginning of 2012. Therefore, the largest number of productive stems per unit of area was formed throughout this observation period. However, heavy rains and strong wind at the beginning of July wiped out the crops and the spring wheat formed a smaller grain harvest than expected. The year 2013 was characterized by the lowest April average temperature of 5.7°C for the period of 2011–2015, and by very wet conditions. There were several heavy rains in May, and a crust was formed on the surface of the soil which bent the sprouts to the ground. The wet early June also affected the spread of fungal diseases (*Blumeria graminis*). In July, the weather was favourable for the spring wheat grain formation and maturation. In April 2014, the moisture in the soil was sufficient for the spring wheat germination and tillering. However, in July, because of an uneven distribution of rainfall and higher air temperatures the side stem formations were reduced and the crop thinned out. However, this year the grain yield was the highest during the observation period. In 2015, the weather was favourable for spring wheat sowing and germination. But the end of May and the 1st and 2nd ten-day periods of June were very droughty. So the soil dried up while the wheat crop was rare. This was the only year out of the five years when the crop was rare and the spring wheat formed the least number of productive stems, but the ears had more grains and they were much heavier than in the other years of the study.

The data of the research were evaluated using the dispersion analysis method (ANOVA) with the SELEKCIJA software package (Raudonius, 2017).

3. Results and discussion

The monitoring of mineral sulphur in the soil carried out in Lithuania showed that in the spring 2011, 2012, 2013, and 2015 the content of mobile sulphur in soil was very low or low (Table 1). This reduction, as indicated by the previous sources, was due to the increase in fertility of other rotational agricultural crops, bigger areas of rape crops and better precipitation during the winter period (Mašauskas, Mašauskiene, 2005; Mažvila et al., 2007; Adomaitis et al. 2010; Staugaitis et al., 2017). Meanwhile, the levels of mobile sulphur in the soil were higher in 2014. This could be a reason of the rather droughty winter and the weather conditions in spring, leaching out less sulphur from the soil. In addition, large amounts of sulphates in the layers from 1.5 to 2.5 meters, with less precipitation and in dry soil, might rise along the soil capillaries to its upper layers (Staugaitis et al. 2015; Piotrowska-Długoż et al., 2017). The amount of trace elements found in the cultivated soil layer during the years of research are presented in the table.
Table 1. Concentration of microelements (mg kg\(^{-1}\)) in the soil

<table>
<thead>
<tr>
<th>Microelements</th>
<th>Years</th>
<th>BBCH 29</th>
<th>BBCH 45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
</tr>
<tr>
<td>S</td>
<td>11.7</td>
<td>5.6</td>
<td>12.2</td>
</tr>
<tr>
<td>B</td>
<td>1.18</td>
<td>0.42</td>
<td>1.41</td>
</tr>
<tr>
<td>Cu</td>
<td>3.49</td>
<td>2.49</td>
<td>4.12</td>
</tr>
<tr>
<td>Mn</td>
<td>129.30</td>
<td>78.40</td>
<td>63.00</td>
</tr>
<tr>
<td>Mo</td>
<td>0.31</td>
<td>0.13</td>
<td>0.02</td>
</tr>
<tr>
<td>Zn</td>
<td>3.07</td>
<td>1.93</td>
<td>1.74</td>
</tr>
<tr>
<td>Fe</td>
<td>13207</td>
<td>13513</td>
<td>14360</td>
</tr>
</tbody>
</table>

The sulphur content in the spring wheat plants in the BBCH 29 growing period ranged from 0.12 to 0.26% (Table 2). The minimum sulphur content was found in 2014, although in the spring of this year, mineral sulphur soils were the highest in the soil. The sulphur content in the summer wheat plants in the BBCH 45 growing period ranged from 0.05 to 0.14%.

Table 2. Sulphur content (%) in spring wheat plants in absolute dry matter

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Years</th>
<th>BBCH 29</th>
<th>BBCH 45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>0.26±0.02</td>
<td>0.14±0.01</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>0.23±0.02</td>
<td>0.09±0.00</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>0.17±0.00</td>
<td>0.05±0.00</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>0.12±0.00</td>
<td>0.07±0.00</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>0.20±0.00</td>
<td>0.09±0.00</td>
</tr>
</tbody>
</table>

The sulphur content in grain of spring wheat ranged from 532 to 1350 mg kg\(^{-1}\), in straw – from 545 to 820 mg kg\(^{-1}\) in absolute dry matter (Table 3). In 2012 sulphur content in grain and straw has not been determined.

Table 3. Sulphur content (mg kg\(^{-1}\)) in spring wheat in absolute dry matter

<table>
<thead>
<tr>
<th>Years</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>In grain</td>
<td>532</td>
<td>-</td>
<td>706</td>
<td>1350</td>
<td>1246</td>
</tr>
<tr>
<td>In straw</td>
<td>820</td>
<td>545</td>
<td>700</td>
<td>780</td>
<td></td>
</tr>
</tbody>
</table>

Moderate to very high levels of mobile boron were found in the fields. A statistical analysis revealed that boron in the soil reduced the amount of sulphur in spring wheat leaves and straws (Fig. 1).

Fig. 2. The influence of soil manganese on sulphur content in the spring wheat plants (a) and straws (b)

During the years of research, the amount of mobile molybdenum in the soil varied greatly from 0.02 to 0.31 mg kg\(^{-1}\) in the spring. In accordance with the data of our research, this element stimulated the absorption of sulphur, establishing reliable positive correlations between the molybdenum content in the soil and the sulphur content in spring wheat plants and straws (Fig. 3). Synergistic relationships between molybdenum and sulphur are also confirmed by other researchers (Rietra et al., 2017). There is evidence that molybdenum is involved in the transport of sulphates (Fitzpatrick et al., 2008). The studies were carried out in neutral reaction carbonate, phosphorous-rich soils where small amounts of zinc are detected. In the years of research, the levels of mobile zinc were found to be from very low to high. There are reports in the literature that zinc increases the sulphur content of wheat straw and grains (Dewal, 2004). In our study, zinc also had a positive effect on the absorption of sulphur, and we obtained reliable correlation between the zinc content in the soil and the amount of sulphur in spring wheat plants during the stages BBCH 29 and BBCH 45, and in wheat straw after harvesting (Fig. 4).
Meteorological conditions have a significant impact on the yield and vegetation of plants. Many publications have found that grains was strongly influenced by meteorological conditions during precipitation in June and July (r = 0.693*, -0.694*). In addition, a weaker but also reliable correlation was found between the content of sulphur in grains and the amount of precipitation in June and July (r = 0.693*, -0.694*).

4. Conclusion

During the study, we found the levels of 6 trace elements (boron, copper, manganese, molybdenum, zinc and iron) in the soil. Four of them had a statistically significant influence on the sulphur content of spring wheat plants. Manganese, molybdenum and zinc positively correlated with the sulphur content in the plants in stages BBCH 29 and BBCH 45 and with the sulphur content in straws. Boron in the soil reliably reduced the amount of sulphur in plants and straws. Meteorological conditions in June and July were the main influencers of sulphur content in cereals.

5. Reference

gestalten. Fachzentrum Land- und Ernährungswirtschaft. DLG 373. 5. 2012. P.4-26 (in German)


ROAD EFFECTS ON VEGETATION COMPOSITION AND SOIL PROPERTIES IN GOL-E-GOHAR REGION (KERMAN PROVINCE, IRAN)

Naseri H.R, PhD. 1, M.Sc. 2 Shahbodaghi J, PhD. 1, Yousefi Khanghah S., PhD. 4, Baba Akbari M, M.Sc. 2, Iman Atighi 3
International Desert Research Center, University of Tehran, Iran 1
Golgohar Mining & Industrial Co. Iran 2
Khatam-o- Alanebia industrial University of Bebahan, Iran 3
University of Zanjan, Iran 4
hrnaseri@ut.ac.ir

Abstract: Construction of the road in the saline area can alter plant communities and diversity. To determine the road effect on plant community composition and diversity in the saline environment around Gol-E-Gohar region (Kerman province, Iran), we conducted a study along roads of Sirjan- Gol-E-Gohar Iron ore and in nearby non-road (i.e. natural) areas in the rangelands of Kaviz Kouh, Sirjan. In addition to plant richness, diversity and composition of plant communities along this roads, we evaluated physiochemical changes in soil of roadside and non-road areas. Floristic data and soil samples were collected along the roadside of Sirajin – Gol-E-Gohar and nearby Kaviz Kouh. To evaluate plant communities at each site, 30 1 m × 1 m quadrats were placed at 10-m intervals along roads and 30 quadrats were arranged randomly in non-road areas. To determine the difference in plant community composition between roadside and non-road areas, we measured species richness and diversity in each site by Shanon index. Plant community (species richness, diversity) and soil physicochemical properties (pH, salinity, ESP, SAR, Lime, Gypsum and Texture) were compared between roadside and non-road areas by using t-tests. Results showed species richness and diversity in roadside areas was significantly higher than in non-road areas and higher Shannon index indicated that roadside can support more species composition. The plant communities in roadside areas had lower percentages of Chenopodiaceae family and had the higher percentage of Asteraceae, Poaceae and Brassicaceae family in plant composition. Compared to non-road areas, activities associated with roads significantly decreased, bulk density and salinity and increased soil pH and sand. According to results road Construction in the saline area of Gol-E-Gohar can improve portion non Halophyte species in plant composition and alter soil properties just along the roadside.

Keywords: PLANT DIVERSITY, SALINE REGION, ROAD BANK, GOL-E-GOHAR, IRAN

1. Introduction

Roads make a crucial contribution to economic development and growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. In addition, providing access to employment, social, health and education services makes a road network crucial in fighting against poverty.

Transport is a significant sector in the economy especially in arid and semi-arid vast area because, by transport systems, culture and wealth are distributed in remote areas. The transport sector can be divided into transport ‘overland’, which includes road haulage and rail carriage; transport ‘over water’ which includes sea freight and inland shipping; air transport; and services with regard to the transport sector. Each category includes the transport of both freight and people. Road transport is the main and rapidly growing category of Iran transport sector. The road transport sector covers several subsectors, which are characterized by varying activities(Hesse & Rodrigue, 2004).

One of the most important parts of mining activities is transportation and these activities depend on the road. The construction of different soil roads or asphalt can help to transport mineral products but road construction can affect nature and these effects can be positive or negative.

The vegetation cover in arid zones is scarce, but it has a vital role in maintaining an ecological balance and improving the livelihood of people in the arid regions(Lambin et al, 2001).

The construction of roads is accompanied by a change in nature and plants are the first part that changes in this process. Therefore, it is very important that the vegetation cover is studied for the planning and management of natural resources, in order to achieve sustainable development in the mining industry. In this study, the effects of road development on vegetation cover were investigated in the Gol-e-Gohar zone. This zone is an important area in the Iranian steel industry and located on the main Sirjan path to Shiraz.

The aim of this study is to examine the effect of the road on the natural vegetation cover of the region.

2. Materials and Methods

2.1 Study area

This research has been carried out during summer 2017 along the Main road of Sirjan to Gol-e-Gohar mining zone (Fig. 1). The study area is located in latitude between 3240504.8m to 3229551.4m N and in longitude between 358304.6m to 346463.9m E nearby Sirjan salt lake. It is a playa with a temporary saline lake located in the west of Gol-e-Gohar mining zone (Fig. 1). The average elevation of the study area is roughly 1700 meters above sea level. Much of the study area is covered with saline soil, which is occupied by native halophytes, e.g., Halocnenum strobilaceum M.B. and Seidlitzia rosmarinus (Ehrh.) Bge. During a 15-year-period, mean annual precipitation is 124 mm in the plain and about 70% to 80% of the annual precipitation is concentrated in the months from September to March, while less than 5% occurs in the summer months (Naseri, 2016). The average annual temperature is 18°C, but significant variations nonetheless occur. According to Do marten drought index (Mashari Eshghabad, 2014), the study area is located in the dry regions by 4.6 of drought index. Temperatures are extremely high in summer, the hottest month being July. The landscape is defined by a series of mostly short mountain and plain. From a geological point of view, Most of the roads are located on plains that are mostly deposits of the fourth geological period (quaternary). The main soil categories in the region include Aridisol and Inceptisols (Jafari et al, 2009).

2.2 Methods

Floristic and soil samples were collected along the roadside of different parts of Sirjan to Gol-e-Gohar road and nearby non-road areas. To evaluate plant communities at each site, 30 1 m × 1 m quadrats were placed at 10-m intervals along roads and 30 quadrats were arranged randomly in non-road areas. Thus, at each roadside site quadrats were placed in a line alongside the road (0–3 m from the road), and in non-road sites, the 30 quadrats were placed random- systematics. Within each quadrat, we identified and counted all vascular plants.
In addition to floristic composition, to determine the difference in plant community composition between roadside and non-road areas, species richness and diversity were evaluated in each site by the total number of species and Shannon–Wiener Index.

Soil samples were taken from topsoil up to 50 cm deep for each site (totally 10 samples for two different site) by profile digging. All samples saved in plastic bags and transferred to soil lab of International Desert Research Center at University of Tehran and Soil physicochemical properties include pH, salinity, ESP, SAR, Lime, Gypsum, and Texture were determined according to standard methods.

Soil reaction (pH) and electrical conductivity (EC) were measured in The saturated soil extract. Particle size according to the hydrometer method (Bouyoucos, 1962) was also calculated. Exchangeable bases were extracted with 1.0 M ammonium acetate solution at pH 7.0. Sodium and potassium contents in the extract were determined by flame photometry while calcium and magnesium contents were obtained by atomic absorption spectrophotometry. Thomas (1982) method was used for the determination of exchangeable acidity. Cation exchange capacity (CEC) was determined using the ammonium distillation method. Total exchangeable bases and percent base saturation were then calculated using values obtained from the exchangeable bases and exchangeable acidity.

Exchangeable sodium percentage (ESP) was calculated by using the equation below: ESP = (Exchangeable Na/CEC) × 100. For calculating the sodium adsorption ratio (SAR) the below formula were used: SAR = Na+/[[(Ca2+ + Mg2+)/2]0.5.

According to Richard (1954), gypsum was calculated. Amount of lime also was determined by using calcimeter methods. Finally, after normalization of data, statistical analysis was performed in the T - Student method and the comparison of means was done by SPSS ver 15 software.

3. Result and discussion

The results of this study include identification of 93 species related to 30 family and Asteraceae(14.1%), Chenopodiaceae(9.7), Poaceae(9.7%), Papilionaceae(7.6%) and Brassicaceae(6.5%) are the most important available families of this region and comprise 47.6 % of overall species. Overall, 89.2% of the species were found in roadside areas, while 25.8% were found in non-road areas, this means that up to 74.2% of the plant species only occurred in areas along road meanwhile just 15.5% of plants species occurs in both area as common species.

Species richness and diversity in roadside areas was significantly higher than in corresponding non-road areas (Fig. 3 and 4) but homogeneity of plants in non-road area is higher than roadside( fig. 4), this factor could reflect the impact of human activities in arid and semi-arid area as fingerprint (Barbier et al, 2006). Low homogeneity means that distribution of plant species is not equal, that’s predictable in roadside because the passage of vehicles, especially agricultural machines, could propagate the plants. However it increases the plant diversity, but in other hands, it reduces the homogeneity.

The soils in the roadside areas were more acidic than in non-road areas (Table 1), but no significant difference in soil pH was found between them. For other parameters, there is the significant difference between two area(Table 1) and this means road construction has a profound effect on the soil properties, For example, adding sand to topsoil for First preparation of road – building alters heavy soil texture to sandy. Water table salinity is controlled by sandy soil and consequently more species plants appear on this type of soil because low salinity provides the better condition for germination and plant growth(Ben-Hur et al, 1985).
It is very clear that a large amount of soil is transferred from the soil during the road construction by moving the soil from other parts, the soil texture changes, and this change could alter the physicochemical properties of soil.

While the Chenopodiaceae family is dominant family naturally in a non-road area and upper than 65% of plants belong to this family in roadside the Asteraceae family shows more species. Salt tolerance species like Halocnemum strobilaceum and Seidlitzia rosmarinus belong to Chenopodiaceae plant family and their presence indicates the concentration of salt in soil and clay texture. Establishment of Nitraria shoberi proves soil condition is favorite for pssamophyte plants because this specie is an indicator of sandy soil (Naseri, 2014). Indeed, some studies have suggested that the role of roads as suitable habitats are superior to their function as potential conduits because the availability of suitable habitats for colonization and establishment of plant species are necessary before populations begin to spread (Sykora et al., 2002).

Zheng et al(2011) state that roads help to decrease soil salinity alongside roads, similar to the agricultural method. The roadbed is elevated in construction, and the terrain of the road and shoulder are slightly higher than the natural areas. Additionally, road effects may mitigate salinization by directly or indirectly changing water availability along roads. The abundant runoff from road surfaces forms gullies that go from the roadside to natural habitats (Forman et al, 2002). In spite of the positive effect of the road, the high concentrations of roads may cause damage to natural vegetation and biodiversity during long periods.

5. Conclusion

Results show that roads have a significant impact on vegetation and soil properties. Road construction increase plant diversity and change species composition by providing favorable habitats for plant species and most importantly decreased salinity stress. As a result, more non-halophytic plants survive in the roadside area, while halophytic plants dominate in non-road areas.

Acknowledgement

we would like to express our deepest appreciation to Golgohar Mining & Industrial Company and all those who provided us the possibility to complete this research. A special gratitude we give to Mr. Taghizadeh CEO of Golgohar Mining & Industrial Company for financial support of our study.

References


Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., ... & George, P. (2001). The causes of land-use and land-cover change: moving beyond the myths. Global environmental change, 11(4), 261-269.


Table 1: physicochemical properties (mean ± stand error) of soil samples taken from study area

<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Roadside</th>
<th>Non-road</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.1±0.1</td>
<td>7.9±1.2</td>
</tr>
<tr>
<td>EC(dS/m)</td>
<td>2.5±0.02</td>
<td>29.8±8.6</td>
</tr>
<tr>
<td>SAR</td>
<td>5.6±1.1</td>
<td>15.9±2.25</td>
</tr>
<tr>
<td>ESP</td>
<td>6.5±0.12</td>
<td>18.16±3.5</td>
</tr>
<tr>
<td>Gypsum(%)</td>
<td>0±0.0</td>
<td>18.2±2.4</td>
</tr>
<tr>
<td>Lime(%)</td>
<td>33.2±6.2</td>
<td>10.2±4.1</td>
</tr>
<tr>
<td>Sand(%)</td>
<td>82±11.2</td>
<td>22±5.2</td>
</tr>
<tr>
<td>Silt(%)</td>
<td>9±2.5</td>
<td>26±6.8</td>
</tr>
<tr>
<td>Clay(%)</td>
<td>9±0.9</td>
<td>52±11.3</td>
</tr>
<tr>
<td>Texture</td>
<td>Sandy loamy</td>
<td>Clay</td>
</tr>
</tbody>
</table>
Abstract: The objective of this study was to evaluate the adequacy of wastewater treatment stages used to treat wastewater from the textile industry in relevance to irrigation water standards. Results showed that primary and secondary treatment stages that are applied at the textile factory are not enough to meet the standards and that tertiary treatment is required. Two different processes a destructive removal process and a physicochemical process has been applied. The Fenton process was selected among the advanced oxidation processes, aiming to destroy organic compounds remaining after the activated sludge treatment. The Fenton process was capable in removing about 65% of the COD left after the biological treatment, and the adsorption process on the other hand removed about 50% of the COD left after the biological treatment. More than 95% and 40% of Pt-Co colour unit has been removed by both the Fenton or adsorption process, respectively. The electrical conductivity values were dropped to about 2300 µS.cm⁻¹ after adsorption process only and to about 180 µS.cm⁻¹ after adsorption and reverse osmosis combined processes. The electrical conductivity values were increased after the Fenton process due to iron addition etc. during the oxidation process, but decreased to about 250 µS.cm⁻¹ after Fenton and reverse osmosis combined processes.

Keywords: TEXTILE INDUSTRY, REUSE OF WASTEWATER, IRRIGATION WATER STANDARDS

I. Introduction

Water shortage is an important issue in the Mediterranean region. Future projection with regard to climate change represents higher risks to the water resources. In order to overcome this problem new strategies are continuously developed and applied at different scales. To prevent the overuse of water resources in the agricultural and industrial sectors, the reuse of water in these sectors is practiced in recent years. Since the agricultural sector is the major consumer of water, the reuse of treated wastewater for irrigation is widely applied. The quality of the irrigation water can relatively be lower when compared with the water quality required for industrial and domestic use. However, it was also reported that application of treated wastewater can have some short and long term effects like salinity and pathogen microorganisms (Sjoukse, 2015). Salinity problem occurs if salt accumulates in the crop root zone to a level at which the plant is not able to sufficiently extract water resulting in reduced crop growth. Besides reduced crop growth and plant damage by sodium, chloride, boron, other problems regarding high nitrate, carbonate, bicarbonate, aluminium, iron levels in the irrigation water quality may occur. General parameters used in the evaluation of agricultural water quality are total dissolved solids (TDS), electrical conductivity (EC), temperature, colour, turbidity, hardness, suspended solids, calcium, magnesium, sodium, carbonate, bicarbonate, chloride, sulphate, sodium adsorption ratio (SAR), boron, trace metals, heavy metals, nitrate-nitrogen, phosphate phosphorus and potassium. The water quality becomes more important in regions with high temperatures and low relative humidity, the so-called arid zones, because of increased salt accumulation in soil. Several irrigation water quality standards have been developed by the Food and Agriculture Organization (FAO) (Table 1) and the International Standard Organization (ISO16075-4:2016) to avoid potential effects on the human health and the environment. The World Health Organization (WHO) suggests appropriate wastewater treatment options to attain the necessary irrigation water quality. Besides issues like the salinity and/or toxicity tolerance of crops, other future dynamics related to soil and groundwater quality require continuous research and monitoring. Especially, some persistent organic and inorganic compounds that are not easily degraded in the environment and water treatment units may build up in future and result in long term effects. The adequacy of industrial wastewater treatment level needs to be questioned in case of agricultural re-use.
As known the raw wastewater characteristics does not only change between industrial sectors but also within a specific industrial sector. For instance, the wastewater characteristics of the textile industry changes according to the textile in concern, quantity of water and chemical components used within the process (Ghalay et al, 2014). Table 2 and Table 3 reflect the differences in water consumption and dye types in the textile industry. Wastewater characteristics of three different textile factories studied within the project are presented in Table 4.

Table 2: Water requirements with regard of textile fiber in process

<table>
<thead>
<tr>
<th>Process</th>
<th>Rayon</th>
<th>Acetate</th>
<th>Nylon</th>
<th>Acrylic/Monacrylic</th>
<th>Polyester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scouring</td>
<td>17000-34000</td>
<td>25000-84000</td>
<td>50000-67000</td>
<td>30000-67000</td>
<td>25000-42000</td>
</tr>
<tr>
<td>Salt bath</td>
<td>4000-12000</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bleaching</td>
<td>--</td>
<td>33000-50000</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Dyeing</td>
<td>17000-34000</td>
<td>34000-50000</td>
<td>17000-34000</td>
<td>17000-34000</td>
<td>17000-34000</td>
</tr>
<tr>
<td>Special Finishing</td>
<td>4000-12000</td>
<td>24000-40000</td>
<td>32000-48000</td>
<td>40000-56000</td>
<td>8000-12000</td>
</tr>
</tbody>
</table>

Table 3: Dye types used for different types of fibres

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Dye type</th>
<th>Unfixed dye, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool and nylon</td>
<td>Acid dyes/reactive dyes for wool</td>
<td>7-20</td>
</tr>
<tr>
<td></td>
<td>Pre-metalised dyes</td>
<td>2-7</td>
</tr>
<tr>
<td></td>
<td>After chrome</td>
<td>1-2</td>
</tr>
<tr>
<td>Cotton and viscose</td>
<td>Azoic dyes</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Reactive dyes</td>
<td>20-50</td>
</tr>
<tr>
<td></td>
<td>Direct dyes</td>
<td>5-20</td>
</tr>
<tr>
<td></td>
<td>Pigment</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Vat dyes</td>
<td>5-20</td>
</tr>
<tr>
<td></td>
<td>Sulphur dyes</td>
<td>30-40</td>
</tr>
<tr>
<td>Polyester</td>
<td>Disperse</td>
<td>8-20</td>
</tr>
<tr>
<td>Acrylic</td>
<td>Modified basic</td>
<td>2-3</td>
</tr>
</tbody>
</table>

Table 4: Wastewater characteristics of three different textile factories

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Factory 1 (biological treated)</th>
<th>Factory 2 (untreated)</th>
<th>Factory 3 (untreated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>789.34</td>
<td>1065.40</td>
<td>2366.83</td>
</tr>
<tr>
<td>F</td>
<td>15.42</td>
<td>2.96</td>
<td>38.40</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>425.52</td>
<td>152.75</td>
<td>1291.65</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>279.70</td>
<td>29.40</td>
<td>672.98</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>4048.59</td>
<td>62.88</td>
<td>1161.62</td>
</tr>
<tr>
<td>Na</td>
<td>2389.97</td>
<td>195.96</td>
<td>1073.5</td>
</tr>
<tr>
<td>NH₄</td>
<td>41.53</td>
<td>4.88</td>
<td>-</td>
</tr>
<tr>
<td>K</td>
<td>132.53</td>
<td>6.39</td>
<td>-</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>21.73</td>
<td>4.02</td>
<td>23.15</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>457.06</td>
<td>38.14</td>
<td>1288</td>
</tr>
<tr>
<td>pH</td>
<td>7.84</td>
<td>7.03</td>
<td>9.58</td>
</tr>
<tr>
<td>EC, mS/cm</td>
<td>8.12</td>
<td>0.82</td>
<td>3.37</td>
</tr>
</tbody>
</table>

Wastewaters are to be treated before discharge and the conventional treatment involves primary and secondary treatments and nowadays tertiary treatment steps depending on the discharge environment and/or aim of end use. Advantages and disadvantages of these physical, chemical and biological treatment methods are given by Hai et al. (2007) in detail. A typical treatment sequence, can be seen in Fig. 1, is generally not enough to meet the irrigation water standards. Thus to protect future soil and groundwater quality tertiary treatment is required. Methods used in the tertiary treatment step generally involve advanced treatment method and/or membrane technologies (Fig. 2).

Table 5: The characteristics of raw textile wastewater

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.5-8.2</td>
<td>7.8</td>
</tr>
<tr>
<td>EC (µS.cm⁻¹)</td>
<td>1602-2200</td>
<td>1841</td>
</tr>
<tr>
<td>COD (mgL⁻¹)</td>
<td>87.8-141.0</td>
<td>109.0</td>
</tr>
<tr>
<td>TOC (mgL⁻¹)</td>
<td>18.41-37.65</td>
<td>28.72</td>
</tr>
<tr>
<td>Color (Pt-Co)</td>
<td>120-165</td>
<td>141</td>
</tr>
<tr>
<td>F (mgL⁻¹)</td>
<td>0.418-1.200</td>
<td>0.632</td>
</tr>
<tr>
<td>Cl⁻ (mgL⁻¹)</td>
<td>171.3-260.9</td>
<td>215.1</td>
</tr>
<tr>
<td>NO₃⁻ (mgL⁻¹)</td>
<td>0.309-0.720</td>
<td>0.524</td>
</tr>
<tr>
<td>SO₄²⁻ (mgL⁻¹)</td>
<td>190.5-307.7</td>
<td>188.5</td>
</tr>
<tr>
<td>PO₄³⁻ (mgL⁻¹)</td>
<td>0.235-0.486</td>
<td>0.317</td>
</tr>
<tr>
<td>Na (mgL⁻¹)</td>
<td>264.7-389.9</td>
<td>335.3</td>
</tr>
<tr>
<td>K (mgL⁻¹)</td>
<td>1.440-2.588</td>
<td>2.111</td>
</tr>
<tr>
<td>Mg²⁺ (mgL⁻¹)</td>
<td>4.030-8.490</td>
<td>4.476</td>
</tr>
<tr>
<td>Ca²⁺ (mgL⁻¹)</td>
<td>12.91-14.51</td>
<td>13.87</td>
</tr>
<tr>
<td>Al (mgL⁻¹)</td>
<td>0.136-0.390</td>
<td>0.256</td>
</tr>
<tr>
<td>As (mgL⁻¹)</td>
<td>0.004-0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Be (mgL⁻¹)</td>
<td>0.015-0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>B (mgL⁻¹)</td>
<td>0.446-1.049</td>
<td>0.398</td>
</tr>
<tr>
<td>Cd (mgL⁻¹)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cr (mgL⁻¹)</td>
<td>0.054-0.099</td>
<td>0.073</td>
</tr>
<tr>
<td>Co (mgL⁻¹)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cu (mgL⁻¹)</td>
<td>0.002-0.122</td>
<td>0.089</td>
</tr>
<tr>
<td>Fe (mgL⁻¹)</td>
<td>0.063-0.246</td>
<td>0.162</td>
</tr>
<tr>
<td>Pb (mgL⁻¹)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Li (mgL⁻¹)</td>
<td>0.073-0.388</td>
<td>0.262</td>
</tr>
<tr>
<td>Mn (mgL⁻¹)</td>
<td>0.053-0.087</td>
<td>0.067</td>
</tr>
<tr>
<td>Mo (mgL⁻¹)</td>
<td>0.077-0.154</td>
<td>0.128</td>
</tr>
<tr>
<td>Ni (mgL⁻¹)</td>
<td>0.008-0.008</td>
<td>0.008</td>
</tr>
<tr>
<td>V (mgL⁻¹)</td>
<td>0.086-0.108</td>
<td>0.108</td>
</tr>
<tr>
<td>Zn (mgL⁻¹)</td>
<td>0.008-3.136</td>
<td>1.977</td>
</tr>
</tbody>
</table>

Fig. 2 Wastewater treatment scheme involving tertiary treatment step

The objective of this study is to evaluate the adequacy of wastewater treatment stages used to treat wastewater from the textile industry in relevance to irrigation water standards. The study also aims to determine appropriate treatment techniques that enable the removal of persistent organic compounds and ions to meet the required irrigation water quality values.

2. Materials and Methods

2.1. Textile Wastewater

The raw textile wastewater samples were taken from a textile industry located in Tekirdağ Turkey. Different reactive dye colours and various chemicals were used during various treatment stages resulting in the complex composition of textile wastewater. The wastewater samples were taken after the biological treatment unit of the wastewater treatment plant (WWTP). All samples have been kept at 4°C and have been used after sand filtration. The characteristics of raw textile wastewater are presented in Table 5.

Fig. 1 Conventional wastewater treatment scheme

2.2. Treatment techniques

Within the project the wastewater that was collected after biological treatment was treated with the advanced chemical oxidation (Fenton) or adsorption process in order to remove constituent that could have not been removed during the biological treatment. Both techniques have been run as continuous reactor
systems. The peroxide and iron (II) catalyst concentrations used were 10 mM and 2 mM, respectively. The reaction time was 10 min for the Fenton process. Natural clay (425-600 µm) was used in the column study. Before use in the adsorption experiments, the clay was crushed and sieved into different grain sizes. Adsorption experiments were carried using natural sepiolite and real textile wastewater. The influence of contact time (5-1440 min; clay <425 µm), adsorbent dosage (10-150 g/L; clay <425 µm) and grain size (<425, 425-600 and 600-1180 µm) was determined earlier.

2.3. Analyses
The performance of treatment techniques were evaluated by differences in chemical oxygen demand (COD), colour (Pt-Co unit), electrical conductivity (EC) and pH. COD, representing organic compounds that can be chemically oxidized, were analyzed according to closed reflux method described in APHA-AWWA-WPCF (1998). The colour was measured as platinum cobalt unit at 465 nm using HACH Lange DR6000 UV-VIS spectrophotometer. pH and EC were determined with Thermo Scientific Orionstar pH meter and conductivity meter. The anions were analyzed by ion chromatograph (IC) and the cations and metals were determined by using inductively coupled plasma spectrometer (ICP-OES).

3. Results and Discussion
Results showed that primary and secondary treatment stages are not enough to meet the standards and that tertiary treatment is required (Table 6). The activated sludge treatment process in use at the factory only enables the removal of easily decomposable organic compounds, generally leaving organic molecules behind that are more persistent in the environment. As the textile uses many types of dyes and other chemical constituents in the scouring, bleeding, dyeing etc. processes it can be assumed that these persistent organic compounds are more of industrial origin. Thus, in case of agricultural use these compounds may accumulate in the soil and finally leach to the groundwater. To avoid such a long term effect additional water treatment techniques are needed to be applied before use.

In this study, the Fenton process was capable in removing about 65% of the COD left after the biological treatment, and the adsorption process on the other hand removed about 50% of the COD left after the biological treatment. More than 95% and 40% of Pt-Co colour unit has been removed by both the Fenton or adsorption process, respectively. The electrical conductivity values were increased after the Fenton process only and dropped to about 2300 µS.cm⁻¹ after adsorption process, respectively. The electrical conductivity values were decreased after the Fenton process due to iron addition etc. during the oxidation process, but increased to about 5220 µS.cm⁻¹ after Fenton and nano-filtration and 19,150 µS.cm⁻¹ after Fenton and reverse osmosis combined processes. Changes in the ionic constituents in the textile wastewater after treatment can be seen in more detail in Table 6.

Membranes are expected to remove target compounds depending on the pore size of membrane. In this study nano-filtration (NF) was applied to see how much of larger divalent ions like calcium sulphate can be removed. As smaller monovalent ions like sodium chloride are not hold by the NF, reverse osmosis (RO) was applied. RO is known to remove all smaller and larger ions in the solution. RO can be applied directly to pre-treated wastewaters. However, to prolong the life time of RO membrane, micro and ultra-filtration membranes are in place before the RO membrane unit. In this study, a destructive removal process the Fenton process was applied to reduce the contaminant level in the wastewater which will in turn lower the strength of concentrate obtained from the RO unit. Membrane technology work like filtration and therefore always generates a concentrate that will need to be processed before final discharge. Using a destructive process like Fenton enables a deterioration in the fouling of membranes and thus prolong their life time.

### Table 6: The characteristics of textile wastewater after treatment

<table>
<thead>
<tr>
<th></th>
<th>RO</th>
<th>F-RO</th>
<th>ADS+RO</th>
<th>ADS+NF</th>
</tr>
</thead>
<tbody>
<tr>
<td>F (mg/L)</td>
<td>0.019</td>
<td>0.014</td>
<td>0.109</td>
<td>0.077</td>
</tr>
<tr>
<td>Cl (mg/L)</td>
<td>5,813</td>
<td>6,783</td>
<td>5,135</td>
<td>38,352</td>
</tr>
<tr>
<td>Br (mg/L)</td>
<td>0.017</td>
<td>0.016</td>
<td>0.008</td>
<td>0.067</td>
</tr>
<tr>
<td>NO₃ (mg/L)</td>
<td>0.892</td>
<td>2.147</td>
<td>0.569</td>
<td>0.414</td>
</tr>
<tr>
<td>SO₄ (mg/L)</td>
<td>0.974</td>
<td>3.483</td>
<td>1.053</td>
<td>4,549</td>
</tr>
<tr>
<td>PO₄ (mg/L)</td>
<td>0.087</td>
<td>0.018</td>
<td>0.038</td>
<td>0.012</td>
</tr>
<tr>
<td>Na (mg/L)</td>
<td>8,791</td>
<td>8,683</td>
<td>9,408</td>
<td>34,34</td>
</tr>
<tr>
<td>K (mg/L)</td>
<td>-</td>
<td>0.045</td>
<td>-</td>
<td>0.020</td>
</tr>
<tr>
<td>Ca (mg/L)</td>
<td>-</td>
<td>-</td>
<td>0.156</td>
<td>-</td>
</tr>
<tr>
<td>Mg (mg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B (mg/L)</td>
<td>0.364</td>
<td>0.360</td>
<td>0.406</td>
<td>0.587</td>
</tr>
<tr>
<td>Al (µg/L)</td>
<td>-</td>
<td>-</td>
<td>1.029</td>
<td>1,518</td>
</tr>
<tr>
<td>As (µg/L)</td>
<td>4,720</td>
<td>4,685</td>
<td>4,758</td>
<td>4,761</td>
</tr>
<tr>
<td>Ba (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Be (µg/L)</td>
<td>15,79</td>
<td>15,77</td>
<td>15,78</td>
<td>15,80</td>
</tr>
<tr>
<td>Bi (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cd (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Co (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cr (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cu (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fe (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hg (µg/L)</td>
<td>42,11</td>
<td>45,50</td>
<td>44,47</td>
<td>40,00</td>
</tr>
<tr>
<td>Li (µg/L)</td>
<td>29,81</td>
<td>29,72</td>
<td>29,98</td>
<td>31,44</td>
</tr>
<tr>
<td>Mn (µg/L)</td>
<td>-</td>
<td>2,107</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mo (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ni (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pb (µg/L)</td>
<td>-</td>
<td>5,798</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sb (µg/L)</td>
<td>18,42</td>
<td>-</td>
<td>85,29</td>
<td>522,0</td>
</tr>
<tr>
<td>Se (µg/L)</td>
<td>6,035</td>
<td>6,743</td>
<td>6,318</td>
<td>7,002</td>
</tr>
<tr>
<td>Si (µg/L)</td>
<td>43,78</td>
<td>20,46</td>
<td>175,1</td>
<td>955,6</td>
</tr>
<tr>
<td>Sr (µg/L)</td>
<td>7,587</td>
<td>7,101</td>
<td>19,15</td>
<td>8,141</td>
</tr>
<tr>
<td>V (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zn (µg/L)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

4. Conclusion
Laboratory studies showed that conventional treatment techniques are not sufficient in achieving irrigation water standards. Membrane technology is needed as a polishing step capable in removing ions that may cause in salt accumulation. The use of a destructive removal process like the advanced oxidation process enables degradation of larger organic molecules that may be persistent in the environment. Fenton combined with membrane technology are appropriate methods to achieve the required standards, also capable in prolonging the life time of membranes.

5. References
PROTECTION OF SOILS AND WATER RESOURCES AS AN IMPORTANT FACTOR IN FORMING PREPARATION TO THE PROJECT ACTIVITY OF FUTURE AGROENGINEERS IN INSTITUTIONS OF HIGHER EDUCATION

Candidate of Technical Sciences, Associate Professor Viktor Pryshliak
Ukraine, Vinnytsia National Agricultural University
victor.pryshlyak@i.ua

Summary. Here are presented the results of scientific researches on the study of the bases of protection of soils and water resources by future agroengineering specialists in higher education institutions. In the educational process of agroengineering training, it is important to develop a motivational and cognitive criterion of preparing the future specialists for the project activity on the basis of fundamental knowledge of the mechanical and technological properties of agricultural materials such as soil, water, fertilizers, pesticides, plants, shrubs, trees, as well as other additional products and agricultural waste, etc., for the purpose of carrying out the necessary environmental measures that will ensure the optimization of the parameters of technological processes, machines and structures which are being developed, constructed and projected. Innovative pedagogical technology of teaching is developed according to the method of gradually increasing the amount of educational material, which comes as a result from previously learned and mastered material. It is recommended that about 20% of the training program for agroengineering to be directed by obtaining general and special environmental competencies. The acquired special professional skills of agroengineers will ensure the development of project activity on the basis of preservation and multiplication of natural resources.

KEYWORDS: AGROENGINEERING, TECHNOLOGICAL PROCESS, TECHNOLOGY TRAINING, METHODOLOGY, SOIL, AGRICULTURAL MACHINERY, SLOPES, WATER EROSION.

1. Introduction

One of the prerequisites for Ukraine's entry into the European community of higher education is full implementation of the ideas of protecting the natural environment within the educational process, scientific activity, organizational and educational work. Environmental protection system of educational process organization in pedagogical technologies of forming the readiness for future activities of future specialists in agroengineering is a model of cross-cutting preparation based on the combination, identification and professional understanding of ecological problems on soil protection, water resources and the influence of this choice on the technology of cultivating agricultural crops, as well as the use of technical means of agricultural mechanization. The purpose of implementation of the environmental system of the organization of the educational process is to expand means for the protection of soil and water based on improving the quality of training of agroengineering specialists and, accordingly, ensuring their competitiveness in the labor market and the prestige of Ukrainian higher education in the world educational space. Formation of the environmental outlook and culture in the pedagogical technologies of project preparation of agroengineering is one of the main components of the organization of problem learning. It is recommended that about 20% of the educational program for agroengineering training to be directed by obtaining general and special environmental competencies, that is, they should be fully aware of the problematic issues of soil and water protection in Ukraine and in the world as in general and to be able skillfully prevent the deterioration of the ecological condition in case of its occurrence.

Prerequisites and means for solving the problem

At the International scientific conference “Conserving soils and water”, which was organized by a Scientific-Technical Union of Mechanical Engineering (Sofia), which took place on 31.08-03.09.2016 in Burgas (Bulgaria), a report was presented «The peculiarities of the work of tillage machines on the sloping lands» [1], in which the problematic issues of agriculture on the slopes are considered, and as a result are shown the methodological aspects of theoretical analysis, experimental research and production verification of the work of soil machinery in these conditions are presented, taking into account the soil fertility, as well as the optimization of the state of water resources is worth noting that in the technology of growing crops on sloping lands can be used general purpose vehicles, although the use of special tools, such as those considered in [2] is more expedient. The world agricultural science and practice are leaning towards the use of soil protection technology, which means the cultivation of soil without rotation of the upper formation layer. As shows the practice and results of plow research with plow crowns are used in some farms, however, scientists are advised that the area of irrigated agricultural land shouldn’t exceed 30%. The world experience in farming shows that the technology of “zero tillage” is gaining in popularity, that is, sown crops without breaking the upper layer of the soil. This technology stabilizes the microbiological complex in the soil, and organic residues contribute to the accumulation of moisture and suppression of seed germination, growth and development of weeds. At the II International Scientific Conference "Protection of Soils and Water Resources", which took place from 30.08 to 02.09.2017, a report was presented in Burgas (Bulgaria) «The main components of studies and research of conserving soils and water in technologies of agroengineers training” [3]. This report partially discloses the scientific and methodological bases for soil and water exploration by future specialists in agroengineering in higher education institutions. Innovative pedagogical technology of development of project activity is developed in the form of a method of a consistent cross-cutting study of the material based on the objective relationship of disciplines and provides a qualitatively higher level of formation of professional competencies of agroengineers on the basis of preservation and even multiplication of natural resources. The report of [3] states that the current issues of soil science are devoted to many works by well-known scholars M. Syckul, P. Zaichi [4], N. Dol, O. Hnatenko, L. Petenko, M. Kapshtika, M. Manojlović [5], R. Meissner [6] and others. An especially important scientific and production problem is the optimization of nutrient and water regimes of the soil on the slopes. A number of scientific works are devoted to the features of soil preparation for sowing crops on sloping lands, optimization and management of technological processes in these conditions. These include [1, 7, 8]. The role of science in the educational process is growing more and more. The classical, practically oriented, as well as the most up-to-date developments and developments of scientists in the form of didactic materials are covered in textbooks, manuals, methodological developments, and they are used in the training process of agroengineering.

It is worth noting that due to the considerable scientific contribution of scientists, agroengineering pedagogical science and educational practice have great achievements. Significant contribution to the development of the theory and methods of vocational education were done by I. Bender [9], V. Duganets [10], V. Manko [11], O. Kulchytska, I. Lerner. V. Rybalka, M. Dumchenko, N. Kuzmina, P. Luzan, and others.

Over the past decades, theoretical and experimental studies
of the impact of design training on the formation of professional competencies of future specialists in agroengineering, the results of which are presented in [12], are conducted on the basis of agrarian universities of Ukraine. In [13], the peculiarities of using the method of projects in pedagogical theory and practice of forming professional competencies of future agroengineers in higher education institutions are highlighted. The method of projects in pedagogical teaching technologies involves solving actual production of problems in agrotechnical issues. With the help of this method, a concrete result is obtained in the form of innovative scientific and technical documentation or other product, that can be presented, publicly defended, passed on to the customer.

The textbook [Ma], which consists of the theoretical part, a block of laboratory work and test tasks, is widely used in the educational process for the agroengineering preparation. It presents the results of research on the man-caused pollution of soils, their detoxification and recultivation, describes the design, methodology of calculation and design of machinery and equipment for land preparation to develop, culturotechnical works and irrigation of fields, regulation of water regime of the soil, laying open channels, their maintenance and purification, formation of anti-erosion screens of irrigation systems, determination of the stability of the bulk part of anti-erosion structures on slopes, studying the influence of soil categories on productive level and its resistance to the bulldozer and other field machinery, etc.

The discussed accents of scientific issues are prerequisites and means of paradigm and didactics for solving actual problems of protection of soils and water resources in pedagogical technologies of forming readiness for future activities of future specialists in agroengineering in higher education institutions.

2. Results and discussion

As noted in [3], an important factor in preparing for the project activity of future specialists in agroengineering in higher education institutions is a fundamental study and comprehensive study: the state of soil with the detailed composition of their mechanical composition (solid, liquid and gaseous); agrophysical (acidity, percentage of humus, nitrogen, phosphorus, potassium and other chemical elements) and technological properties (hardness, characteristics of external and internal friction, resistance to deformation, viscosity, adhesiveness, plasticity, abrasiveness, ability to loosen and shred, etc.); water regimes; machinery and technology.

Studying the role of soil in the biosphere, students understand that soil is an indispensable intermediary between inanimate and living nature, and a very important link in various cycles that goes through the perimeter of the geographic envelope. If this link is destroyed, for example, by soil erosion processes or by various anthropogenic influences, then the natural functioning of the biosphere will be broken. Therefore, now that the land is used intensively for the purposes of agriculture and other economic needs, especially the actual and problematic issues are the protection of soils, which are the basic basis of the planetary living conditions and the restoration of living matter and life on earth.

The main cause of soil pollution is human activity, which is sometimes iliterate and carefree. As a result of the influence of the anthropogenic factor, in particular the irregular, irrational exploitation of land, a large proportion of the fertile layer is the subject to erosion and is lost annually. Thus, over the past 100 years, the process of erosion has captured 27% of the total land area which are occupied by agricultural land.

With the harvest the human withdraws from soil minerals and organic components, thereby impoverishing it. Therefore, it is necessary constantly to replenish the stocks of these substances in the soil by fertilizing it. Carefully cultivating and fertilizing the soil, following the sequence of crops in rotation, one improves soil fertility so that most modern arable soils should be considered artificial, created by human beings. During the design and construction of machinery for agricultural purposes must be skillfully taken into account all environmental properties of machine units, which determine the conditions for combating water and wind erosion, soil compaction, pollution and production of harmful compounds, etc.

Great attention of environmental issues is given to future agricultural engineers studying the agricultural machinery discipline. Here are some of the points of the program of the indicated academic discipline [15], which are largely concerned with environmental issues in agriculture and pedagogical research, which has been given the most attention.

The program [15] has the point 1.1.3. − Machines for soil protection systems of agriculture. It specifies the following questions for study: the main types of machines; the structure and workflow of flat-cutters-deep-thrusters, chisel plows, slit-cutters, etc.; combined soil cultivating units; types of working bodies of machines, aggregates, their main parameters; hydro equipment; technological adjustment of machines and aggregates, control and evaluation of the quality of soil cultivation; safety measures.

According to this paragraph, students study methods of cultivation and machines for controlling water erosion [16], starting with terms, definitions and categories. For example, erosion is called erosion by water washing and wind blowing of fertile soil particles. All soils are more or less vulnerable to erosion. Accordingly, any agricultural machine, and especially a soil cultivation one, to a greater or lesser extent, should be anti-erosion. However, it is generally considered anti-erosion only those machines that carry out operations, the main purpose of which is to combat soil erosion. Such operations include snow removal, terracing, gluing, hanging, loosening of soil with preservation of stubble.

For water erosion, soils are particularly prone at slopes, and the method of their anti-erosion treatment depends on the steepness of the slopes. When steepness of slopes is up to 6°, it is recommended to cultivate the soil with the preservation of the stubble or mulching of the fields, the formation of holes, transverse ridges, and the like. When steepness of slopes is from 6° to 13°, it is expedient to create special rollers, drainage grooves and cracks filled with organic substances (peat, manure, plant remains or branches). When steepness of slopes is more than 13° it is necessary to create terraces. All this kind of work is conducted with plow plows and special machines and machinery.

Students have a formed key content and conceptual device, which is based on the understanding that in the field of plant growing, land resources form the basis of agricultural activities and the soil environment, is the main means of production. The soil is subjected to various impacts on it of mineral fertilizers, pesticides, working bodies, as well as supporting and moving elements of machine-tractor aggregates. It is important that this effect does not destroy the structure of the soil, but retains its natural fertilizing properties, and even better, helps to raise them. Students should be aware that in the future, highly skilled agricultural production specialists should not only prevent negative erosion but also take care of the growth of soil fertility.

During the study of the discipline "Mechanical and technological properties of agricultural materials" [17], students study and investigate the physical and technological properties of the soil as a cultivating object, the harmful effects of the support and propulsion machinery and tractor aggregates on the soil, the mechanical and technological properties of fertilizers as the mechanism of mechanized introduction into the soil, the properties of the sowing material, the technological properties of the pesticides used for the protection of plants, etc.

The curriculum of the subject "Agricultural Machines" [15] provides for the completion of the course work [18], which is the final stage of studying the discipline. For each of the topics of the course work there is a section that reveals the mechanical-technological preconditions for the development of the machine, as well as the issue of environmental protection.

Land reclamation is the most expensive component of the intensification of agriculture. But these costs quickly pay off because the productivity of irrigated land is 4–5, and drained −1.5... 2 times higher than the ones which are not reclaimed. An important role belongs to amelioration in the protection of the environment, and the implementation of measures aimed at the integrated and rational use and protection of water, land and forest resources.
Therefore, the study of land reclamation machines by future agroengineers is of great importance. Students study reclamation machines at lectures, laboratory and practical classes, while undergoing internships, both independently and under the direction of a teacher.

As an example, let’s consider one of the 11 laboratory and practical works (the ninth one) conducted by students of specialty 208 "Agroengineering", studying machines and equipment in agricultural land reclamation – "Justification of the breadth of the berm of the terrain of soil protection technological processes" [14]. The purpose of the work: to study the features of efficient use of sloping lands and to acquire practical skills in preventing erosion processes, as well as to explore the possibility of increasing the soil fertility on the basis of a system integrated approach to the development of technological processes for the construction of terraces using the method of justification of the width of berm.

Initially, future specialists in agroengineering study theoretical positions and conceptual apparatus for the construction of berm terraces, as well as the peculiarities of soil protection processes in the cultivation technologies of various crops and fruit plantations on the slopes. At the initial stage of laboratory work, students study general information on the justification of the breadth of berm terraces. They realize that the berm on a slope separates one terrace from another, and their width must be due to the stability of the terraces in the event of destruction of the slotted slopes. It is known that the stability of the terraces depends on many factors, including slope steepness [3, 14]. Under the condition of placing on the canvas of two rows of fruit trees, the width of the berm is chosen taking into account the optimal distance between the rows of plantations on adjacent terraces.

The most common method for calculating slopes is the method of circular cylindrical sliding surfaces. In the theoretical substantiation of the stability of the bulk part of anti-erosion structures on the slopes one can assume that the surface of the slip is located at the point of intersection of two beams drawn from the top and bottom of the slopes at angles \( \beta_1 \) and \( \beta_2 \) (Fig. 1). It is assumed that the soil is inherent only to the inoculation.

Accepting the center of the arc with the slipping point of intersection of the rays taken at the angles \( \beta_1 \) and \( \beta_2 \), we can say that the actual slip curve in the slope shifts will be left of the curve \( AK \) (Fig. 1), since the soil, besides the inoculation, also has its friction.

In this way, the solution of a problem can be determined by a slightly larger berm width, comparing it with the definition of it by successive approximations, using the method of positioning of circular cylindrical surfaces.

On Fig. 1. \( AB = h \) – the size of the slot, and \( VK \) – the width of the berm. From the drawing it is clear that

\[
OB = \frac{h \sin \beta_1}{\sin (\beta_1 + \beta_2)};
\]

\[
AJ = OK = R = \frac{h \sin (\beta + \beta_2)}{\sin (\beta_1 + \beta_2)};
\]

\[
sin \delta_1 = \frac{OB}{R} \sin (\alpha + \beta_2) \sin \beta_1 \sin (\alpha + \beta_2) \sin (\beta + \beta_2),
\]

from here

\[
\delta_1 = \arcsin \left[ \frac{\sin \beta_1 \sin (\alpha + \beta_2)}{\sin (\beta + \beta_2)} \right].
\]

Then

\[
\delta_2 = 180° - \delta_1 - 180° + \beta_2 + \alpha = \alpha + \beta_2 - \delta_1.
\]

Knowing the magnitude of the angle \( \delta_2 \), we determine the berm’s width by the formula:

\[
a = BK = \frac{R \sin (\alpha + \beta_2 - \delta_1)}{\sin (\alpha + \beta_2)} = \frac{h \sin (\beta + \beta_2) \sin (\alpha + \beta_2 + \delta_1)}{\sin (\beta + \beta_1 + \beta_2) \sin (\alpha + \beta_2)}.
\]

Replacing in the formula (6) the values of \( h \) and \( \delta_1 \) with their determinations, we obtain:

\[
a = B \frac{\sin (\alpha + \gamma) \sin (\beta + \beta_2)}{\sin (\beta - \alpha) \sin (\beta + \beta_1 + \beta_2)} \times \\
\sin \left[ \frac{\alpha + \beta_2 - \arcsin \sin \beta_1 \sin (\alpha + \beta_2)}{\sin (\beta + \beta_2)} \right] \times \\
\frac{\sin (\alpha + \beta_2) \sin (\alpha + \beta_2)}{\sin (\beta + \beta_2)} = B \varepsilon,
\]

where \( \varepsilon \) – is a sampled curve when the width of the berm is \( B \).

The results of the calculating of the level (7) show that due to the terms of change of the steepness of the slope and the width of the level the width of the berm is growing too. According to the agrotechnical demands the fruit trees are planted on the slope in a chess order (Fig.2). In that case the width between the lines of trees \( I_2 \) and the distance between the trees in each row \( I_1 \) will be different.

![Fig. 1. Design scheme for determining the width of berm terraces, taking into account the stability of slopes against its displacement.](image)

![Fig. 2. The calculation scheme for determining the width of the berm on the terraces with two rows of the fruit cultures.](image)

The distance between the fruit trees on both sides of the rhomb:
According to the agrotechnical demands it is allowed to have the variables of data $l_1$ and $l_2$ at the slopes with the changeable steepness. The biggest distance between the fruit trees in the row is:

$$l = 2l_1.$$  (8)

When we have the change of length of the rhomb sides the minimal width of the cross-rowing is:

$$l_{2\text{min}} = \sqrt{l_2^2 + \frac{l_2^2}{4}} = \sqrt{l_2^2 - \frac{3}{4}l_2^2}.$$  (10)

The results determined by the formulæ (10) show that $l_{2\text{min}} > 2l_1$. When $l = 2l_1$ the density of planting is growing up to 18%, at the place of steep slopes with the angle of up to 15° and up to 10% - steepness more than 15°.

By agrotechnical machinery it is allowed to have the change of density of planting the fruit trees up to 20...25%. $l = 2l_1$.

When we have the difference of horizontal lines and the constant width of the berm, the width of the berm can be increased.

Let’s determine the size of the berm for the terraces with the double-row planting (Fig. 2), in order to get the optimal width of double-row between the fruit trees from the side of the steep slope of the lower terrace along with the side of the steep of the upper terrace.

The width of the slope, necessary for the construction of a terrace with double-row gardening of crops (Fig. 2)

$$L = B_2 \sqrt{\frac{\sin(\beta + \gamma)}{\sin(\beta - \alpha)} \sin\beta + a_2} =$$

$$= l_{2n} \cos\gamma \cos\alpha + \sqrt{l_2^2 - \frac{3}{4}l_2^2},$$  (11)

where $B_2$ and $a_2$ – respectively the width of the surface and berm on terraces with double-row plantation;

$L_{2n}$ – the width of the row spacing measured on the surface.

Then the minimum width of berm for terraces with double-row plantation is:

$$a_2 = l_{2n} \cos\gamma \cos\alpha + \sqrt{l_2^2 - \frac{3}{4}l_2^2} - B_2 \sqrt{\frac{\sin(\beta + \gamma)}{\sin(\beta - \alpha)} \sin\beta + \gamma}.$$  (12)

The solution of equation (12) shows that with increasing steepness the width of the berm decreases. The rapid change of the function $a_2 = f(\alpha)$ at $\alpha = 15^\circ$ happens due to the transition of the width of the intermediate row from 6,5 to 8 m. The width of the berm decreases due to the increase in the length of the bulk and slotted slopes and the increase of steepness at a constant (6,5 or 8 m) width of row spacing.

The common solution of equations (3) and (12) determines the steepness in which the width of the berm, which is determined by the stability of the slopes against their destruction, is equal to the width of the berm, which is determined by the optimal density placement of the plants. This equation has the following form:

$$l_{2n} \cos\gamma \cos\alpha + \sqrt{l_2^2 - \frac{3}{4}l_2^2} -$$

$$= B_2 \sqrt{\frac{\sin(\beta + \gamma)}{\sin(\beta - \alpha)} \sin\beta + \gamma}$$

$$= B_2 \frac{\sin(\alpha + \gamma) \sin(\beta + \beta)}{\sin(\beta - \alpha) \sin(\beta - \alpha)} \times$$

$$\times \left[\alpha + \beta - \arcsin\left(\frac{\sin\beta \sin(\alpha + \beta)}{\sin(\beta + \beta)}\right)\right].$$  (13)

The equation (13) can be solved graphically. For $\gamma = 3^\circ$, $\beta = 60^\circ; \beta_1 = 29^\circ; \beta_2 = 40^\circ$ and $B_2 = 6$ m, the value of $\alpha = 19.1^\circ$.

The greatest steepness, in which it is advisable to terrace the slopes, can be determined based on the maximum permissible depth of excavation of the soil.

Prof. A.P. Dragavtsev notes that at a depth of more than 2 m slots there is a slipping and destruction of the slotted slope. Observations by V.S. Fedotov show that at a depth of slots more than 2,5 m the slopes are destroyed.

Consequently, if the maximum permissible depth of the slot is given, one can determine the greatest steepness in the relation:

$$h_{\text{max}} = B_2 \frac{\sin(\beta + \gamma)}{\sin(\beta - \alpha)} + 1$$

$$+ \sqrt{\frac{\sin(\beta + \gamma) \sin(\beta - \alpha)}{\sin(\beta + \gamma) \sin(\beta - \alpha)}}.$$  (14)

At $h_{\text{max}} = 2$ m, $\varphi = 35^\circ; \gamma = 3^\circ; \beta = 60^\circ$ and $B_2 = 6$ m, the value of $\alpha = 19.4^\circ$.

Consequently, the results of the solution of the transcendental equations (13) and (14) almost coincide with the same initial output data.

Students are advised to do the following procedure for performing a laboratory work.

1. It should be noted that this laboratory work is a continuation of the analytical study of the dependence of terrace parameters from the slope steepness index which was initiated in laboratory work No. 8, an example with the solution is given in [3].

2. It is advisable that students must carefully read and validate the main theoretical positions and methodology for justifying the width of the berm terraces when developing the technological processes of soil protection from water and wind erosion and increasing its fertility [14].

3. Based on the initial data from the individual task given by the teacher of laboratory work number 8 in the workbook it is necessary to write the parameters necessary for the calculation, namely: the width of the surface ($B_m$), the angle of inclination of the transverse profile of the surface to the horizon ($\gamma$, °), the angle of the bulk slope ($\varphi$, °), the slope angle of the slot to the horizon ($\beta$, °).

Provided that the slope angle of the slot to the horizon is $\beta = 60^\circ$; take $\beta_1 = 29^\circ$; and $\beta_2 = 40^\circ$.

4. Draw (according to the example of Fig. 2) the calculation scheme of the step terraces and indicate on the scheme the numerical parameters of the bulk part of the anti-erosion structure.

5. By the formulæ (7) of this laboratory work, determine the value $a$ - the width of the berm terraces (m) with the values of steepness of the slope, $\alpha = 10^\circ; 12^\circ; 14^\circ; 16^\circ; 18^\circ; 20^\circ; 22^\circ; 24^\circ; 26^\circ; 28^\circ; 30^\circ$. The resulting calculations are summarized in the table. In addition, draw a graph showing the dependence of the berm's terraces $- a$ (m) depending on the slope steepness $- \alpha$, °.
6. Based on the results of the calculations and the constructed graph, students should formulate conclusions regarding the behavior of the dependence curve of the corn’s terrace - and depending on the slope steepness - α.

According to the results of the laboratory-practical work in accordance with their task, students compile a report covering the theoretical and practical parts and necessarily allocate a point in which they analyze the protection of soils and water resources. The reports are defended by the students to a teacher in the presence of other students, who can in this case obtain additional information, especially in such important areas as environmental protection.

3. Conclusion

In pedagogical technologies of preparation of future agroengineers, formation of their readiness for project activity, considerable attention is paid to the problem issues of soil and water conservation. During the entire period of study, students must study systematically and consistently, to be present at all laboratory and practical classes, they must investigate the mechanical and technological properties of soils as the main means of agro-industrial production and other objects of interaction of working bodies. In the project activity for the initial parameters primary consideration is taken of the soils with their characteristics and parameters with the obligatory preservation of their fertility in the technologies of agricultural production of plant production, as well as the properties of mineral and organic fertilizers, pesticides, various plants, shrubs, trees, agricultural waste. An example is the laboratory and practical work on land reclamation machines, which reflects the scientific capacity of the educational process of agroengineering training in higher education institutions.

4. References


