NEWSLETTER 4 / 1995

E.S.S.C.

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EUROPEAN SOCIETY FOR SOIL CONSERVATION
Second International Congress
DEVELOPMENT AND IMPLEMENTATION
OF SOIL CONSERVATION STRATEGIES
FOR SUSTAINABLE LAND USE

Further Information on Page 20 (AIM: Announcements, Information, Meetings)

E.S.S.C. NEWSLETTER 4 / 1995

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ESSC NEWSLETTER

I regret to announce that due to pressure of work, Dr. John Boardman has asked to be relieved of his duties as Editor-in-Chief of our Newsletter. He has agreed, however, to remain on the editorial board as one of the co-editors.

Until a new Editor-in-Chief is elected at our next Congress in September 1996, the Newsletter will be produced entirely in Trier. All contributions for inclusion in the Newsletter should therefore be sent from now on to Professor Richter. He and I will work together with the editorial board in deciding on any management and policy issues which may arise between now and September.

Please keep your contributions coming in. These can be reports on interesting events, research achievements, conferences; notices of meetings; announcements of staff changes; indeed, any item which you feel would be of interest to others. Please note, however, that the Newsletter is not a scientific journal. We cannot publish scientific articles. Any material of this type which is submitted will be either rejected or very severely edited to fill not more than 2-3 pages so that only the key points are retained.

R P C Morgan
President

UNITARY ENERGY IN MODELLING OF SOIL COMPACTION PROCESSES

Compaction is one of the most important physical properties of soil. Too high compaction of the plough layer may cause a significant decrease in crop yield

A disadvantage of many mathematic models of soil compaction is that they do not take into account the initial value of bulk density of the soil. Consequently, it has to be assumed that prior to the first pass, the soil is maximally loose, and, furter, that the bulk density after a given number of passes will be always the same independent of the speed duration of the passes. These are serious simplifications. Moreover, none of the models considers the speed of passing despite the fact that changes in the speed result in slip loosening of the 0-5 cm soil layer and in change of pressure duration. The effect of an actual machine on soil compaction is represented in the models either by its technical parameters or by pressure exerted by it on a unit area of soil.

The aim of my research is to construct a model without these disadvantages and true for a wide range of agricultural machinery. A very general index of the effect of a machine on the change in bulk density of soil is the amount of unitary energy used by the machine for compacting the soil. This amount can be calculated using the model of compaction energy constructed by S. Podsiadlowski and presented by Podsiadlowski and Walkowiak (1994):

$$(1) \qquad A_c = [A_u - A_t - (1 - E_m)P_t/(E_m W_t) - 0.1P_{wom}/0.9W_t]\, b/2b_t$$

where:

- A_c - *the unitary compaction energy (kJ/m^2),*
- A_u - *total energy per area unit (kJ/m^2),*
- A_t - *unitary energy of tillage (kJ/m^2),*
- E_m - *factor of effectiveness of power transmission system,*
- P_t - *general pulling force of tractor axis (kNm/s),*
- W_t - *effectiveness of tillage work (m^2/s),*
- P_{wom} - *driving power on driving shaft of rototiller (kW),*
- b - *track width (m),*
- b_t - *work width (m).*

Hence, compaction energy A_c is the difference between the amount of all used energy and the amount of energy used for tillage and in overcoming mechanical resistance inside the machine. Input data are tractor weight, weight of a piece of machinery or agricultural tool, tyre width, rate of tillage, soil type (light, medium or heavy).

Equation (1) can be used to modify the modell of Grigoriew et al. (1992) to give:

(2) $$\rho_{vi} = \rho_{vpi} + \frac{(\rho_{v\infty} - \rho_{vpi}) f(A_c)}{g_i f(A_c) + k} \quad i = 1, \ldots, n,$$

n	*- number of soil layers,*
ρ_{vi}	*- bulk density in the i-th layer after a pass,*
ρ_{vpi}	*- initial bulk density in the i-th layer,*
g_i	*- coefficient related to the distance of the i-th layer from the surface,*
$\rho_{v\infty}$	*- limit value of the bulk density for a given soil at a given moisture content,*
A_c	*- the unitary compaction energy,*
k	*- empirical coefficient,*
$f(A_c)$	*- function depending on unitary compaction energy.*

The following functions are considered:

$$f(A_c) = a_1 A_c + a_2$$

(3) $$f(A_c) = a_1 A_c^{a_2}$$

$$f(A_c) = a_1 \ln(a_2 A_c)$$

$$f(A_c) = a_1 e^{a_2 A_c}$$

This model takes into account that, for a given soil type and a given moisture content, there is a limit value for bulk density. This value can be determined using the method of Rzasa and Owczarzak (1990). The higher the pressure force, i.e. the more compaction energy going into the soil, the closer is the bulk density to the limit density. The difference between the initial and the final densities depends not only on the compaction energy but also on the soil compaction and on the depth of the soil layer. The closer is the initial density to the limit one, and the deeper is the soil layer, the more energy is needed for additional compaction of the soil.

The modell of Arvidsson and Håkansson (1991) can also be extended by introducing the initial degree of compactness, replacing compaction potential by an expression dependent on compaction energy, and differentiating with respect to soil layers to give:

(4) $$D_i = D_{pi} + \frac{1 - D_{pi}}{aD_{pi}} [P_2(\text{moisture class}) + f(A_c)], \; i = 1, \ldots, n,$$

n	*- number of soil layers,*
D_i	*- degree of compactness in the i-th layer after passing,*
D_{pi}	*- initial degree of compactness in the i-th layer,*
a	*- empirical coefficient,*
P_2 *(moisture class)*	*- polynomial of the second degree depending on the moisture class,*
$f(A_c)$	*- one of the functions (3).*

Verification of these models will be carried out on basis of empirical data. Therefore experiments will be carried out on various soils using different machinery. Moisture content, initial bulk density, initial degree of compactness, density and degree of compactness after one and several passes at different depths will be measured. For each of the discussed models (2) and (4) and for each of the functions (3) a function will be constructed described by the formula:

$$(5) \qquad \varepsilon = \begin{cases} \sqrt{\frac{1}{m}\sum_{j=1}^{m}\left(\rho_{vij\,exp} - \rho_{vij}\right)^2} \\ \sqrt{\frac{1}{m}\sum_{j=1}^{m}\left(D_{vij\,exp} - D_{vij}\right)^2} \end{cases}$$

for the model (2) or (4) respectively, where:

m - *number of observations,*
i - *number of the soil layer,*
j - *number of the observation,*
ρ_{vijexp} - *bulk density measured in the i-th layer in the j-th point after the experiment,*
ρ_{vij} - *bulk density in the i-th layer in the j-th point calculated from the formula (2),*
D_{vijexp} - *degree of compactness measured in the i-th layer in the j-th point after the experiment,*
D_{vij} - *degree of compactness in the i-th layer in the j-th point calculated from the formula (4).*

For each model (2) and (4) and function (3) the parameters will be selected in such a way so as to minimise the function (5). Finally the model for which the function (5) will assume the smallest value will be chosen as the model of compaction for the i-th soil layer.

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SE-LIST (THE INTERNET SOIL EROSION DISCUSSION LIST): GROWTH AND ACTIVITY IN THE FIRST YEAR

1. Introduction

The Internet SE-LIST ('Soil Erosion Discussion List' - **se-list@uni-trier.de**), which was first announced in ESSC Newsletter 3/1993, has now established itself as a forum for international scientific discussion, with over 325 members from 32 countries. As the first anniversary of this e-mail based list approaches, this article looks back over events during the first year: teething troubles, near abandonment, an eleventh-hour surge in membership, and subsequent developments. Plans for the future are also presented.

2. The history of SE-LIST

2.1 Beginnings

The first author, having searched for (but not found) an Internet discussion list for topics related to soil erosion, and in particular the use of GIS and geostatistics for erosion studies, decided to set up such a list. A first step was to check the technical feasibility of this with the University of Trier Computer Centre. While familiar with the use of list servers elsewhere (such as the USA, UK and Australia), for the people at the Trier Computer Centre actually setting up a discussion list was a new experience. It seemed sensible, therefore, to adopt a cautious approach, using proven rather than novel technology. However this meant sacrificing some desirable features. In particular, all transactions - such as subscribing to or withdrawing from the list - had to be carried out by the list owner. While not a major problem, this approach can sometimes be slightly off-putting to the new subscriber, especially if the list owner is absent for any length of time.

Technical problems (as well as much hard work!) aside, a list was eventually set up. An unmoderated approach was adopted, permitting free and hopefully spontaneous discussion between subscribers. Under this system, any subscriber may send an e-mail message to the list, which will then be distributed to all other subscribers. All subscribers (unless they have temporarily or permanently withdrawn from the list) receive all messages. The only essential task of the list owner then becomes maintenance of the list. However the list owner normally carries out other administrative tasks, such as the collation of particularly interesting sequences of questions and responses into 'Frequently Asked Questions' (FAQ) documents; publication of statistics on list membership; and - though this has not been necessary on SE-LIST so far! - issuing warnings to (or even ejecting) unruly members.

2.2 Early problems

With the groundwork complete, the list was announced in ESSC Newsletter 3/1993, some months after the original idea. But the Internet had not stood still: other related lists (e.g. GIS-L, AGMODELS-L, SOILS-L) had subsequently been set up or grown in size. Possibly because of competition from these lists, SE-LIST failed to grow as hoped. So in the first six months (to August 4th, 1994), the list 'collected' just 21 interested persons!

Although each list member will probably have slightly different research interests, with such a small membership it is very difficult to hold useful discussions, since if a question or comment is posted which requires specialized knowledge for a reply, the likelihood of a list member possessing that knowledge is low. The project was therefore reluctantly scheduled for cancellation by the first author.

2.3 Growth of membership

However following a new initiative from the second author, it was decided to try again, this time widening the context of the list to include both theoretical and practical interests. The intention was that SE-LIST should be a forum for modellers, field and laboratory workers, consultants, teachers and working scientists; and as well as the original themes, the list should also be concerned with subjects as wide-ranging as soil conservation techniques, rainfall simulation and modelling soil erosion under climate change.

This shift of emphasis appeared to do the trick: following further advertisement in both electronic and analogue media the list started to grow. Subsequent growth was both rapid and continuous. From the 21 original members, by the middle of August the number of members passed 100; around one month later (September 9th) the list had 178 members. By the end of October there were more than 200 members: growth then started to level off. Currently the list has 325 members.

3. SE-LIST today

3.1 Membership

Membership is almost worldwide. While the list currently has subscribers from 32 countries, the distribution of members between those countries is very uneven. The USA has 40.3% of list members, the UK 9.9% and Germany 8.6%. These are followed by Australia with 7.3% and Canada with 5.6%. Thus nearly half of all members live in North America, and the five countries so far mentioned account for more than 70%! Membership from the developing countries is low.

What does this mean? It is unlikely that this distribution is wholly or even largely due to a greater perception of soil erosion as a problem within these countries. Widespread availability and use of computers, and access to the Internet seem be major factors; possibly the almost exclusive use of English for discussions on the list is also important. Certainly these would explain the low representation of developing countries; thus the list's potential contribution to those areas of the world with the most severe erosion problems remains limited.

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3.2 List activity

As noted above, the list was perceived as a forum for discussion of all aspects of soil erosion and conservation. In practice, almost all SE-LIST activity has been one of the following:

- requests for information and help
- discussion on problems encountered, and exchanges of opinion relating to general research approaches and methodologies
- announcements.

3.2.1 Requests for information

Requests for information currently make up the bulk of the activity on SE-LIST. A typical sequence of events might be:

- someone encounters an erosion-related problem or question in his or her work
- this person then posts a message to the list, in the hope that other list members have encountered a similar problem
- other members see the message and respond to it. Note that these members respond in their own time (which might be in the middle of the night in the questioner's time zone) and might well be previously unknown to the questioner. Responses may be public (i.e. posted to the list for all to read) or private (sent direct to the questioner's e-mail address)
- if the question has generated useful responses (public or private), the questioner might choose to eventually collate these and send the sequence to the list manager for inclusion in the FAQ documents.

Questions asked on SE-LIST have ranged from the straightforward, such as requests for references and reprints, to theoretical issues relating to aspects of erosion modelling. Samples are:

- the status of RUSLE software (licensed or public domain?)
- bedload transport
- Swarte's ONZAT soil and water simulation model
- the impact and focus of various soil and geomorphological journals
- sediment delivery ratios
- snowmelt erosion in boreal regions.

If questions are very specific, answers usually generate little comment. Sometimes, however, a lengthy discussion can proceed from an apparently simple question.

3.2.2 Discussion

Fundamental discussions are the most interesting class of activity. The informality of lists such as SE-LIST (what weight would you give to a citation of an Internet discussion?) means that opinions are often expressed freely, much as in after-hours conference bar-room conversations (though perhaps with a clearer head!). These exchanges can be vociferous, but (at least on SE-LIST) have so far always been well thought out, stimulating and thought-provoking. However, participation in these discussions could well end up consuming a good share of participants' time. Probably for this reason, this kind of participation does not take place often.

Themes that have been discussed are:

- the availability of computer models for teaching
- the value of models which 'merely' attempt to predict soil loss rates
- off-site impacts of soil loss
- soil quality and soil health
- absolute and relative model estimates of erosion rates.

3.2.3 Announcements

In addition to general information on conferences, and job openings for geomorphologists, soil scientists and geographers, this category has included a wide range of postings. Samples are:

- releases of WEPP (Water Erosion Prediction Program)
- WOCAT (World Overview of Conservation Approaches and Techniques)
- the CIESIN Kiosk.

3.3 Participation levels

During the six months that SE-LIST has been fully active, an active core of SE-LIST members appears to have been established; it is this core who do the most 'work'. This is to be expected: list members may choose not to participate actively if they do not wish to. At the present level of list membership, the numbers of messages generated each day are not excessive (an average of about 1.6); if anything the list is still a little quiet. (This is in welcome contrast, it must be admitted, to some 'hyper-active' discussion lists known to the authors.)

4. The future

A major change is the transfer of list management (from February 1995) to a proper LISTSERV program. Administrative activities such as joining or leaving the list are now fully automated (see below). Linked with this is another ongoing activity: the collection of members' names, addresses and research interests into a database. In the very near future, it will be possible to acquire a copy of this database which may then be searched, both for individuals and for research themes. (Other similar directories already exist on the Internet - for example on GEOMORPHLIST - but are not concerned specifically with soil erosion.) However this database is currently still incomplete.

More ambitious plans include setting up a server for WWW (World Wide Web) access. This would make information available (e.g. the above membership database or the FAQ documents) without assistance from the administrator. At present, funding has been requested from the 'Stiftung Rheinland-Pfalz für Innovation' to buy the hardware necessary for setting up this system.

Finally, despite very encouraging initial growth, SE-LIST still requires more members. Many of the home countries of ESSC members are still under-represented. Could these ESSC members publicize the list to colleagues who might be interested? Only with wider international representation can SE-LIST achieve its full potential: as a tool to assist with the international problem of soil erosion.

5. Joining the list

Since a LISTSERV program ('Maiser') became available for SE-LIST in February 1995, joining the list is now much easier. Interested colleagues need only send a single-line e-mail which contains the the following request:

subscribe se-list

to **maiser@pcmail.uni-trier.de** in order to subscribe.

Maiser has several facilities available. For more details of these, send a single-line e-mail to the same address with the request:

help

in the body of the message (instead of the subscription line). After a short time, you will then receive some information regarding SE-LIST, including general information on participation in discussions. Also it will (soon) be possible to obtain statistics concerning the nationalities of members, plus a list of members (including e-mail addresses). For an overview, send the command:

index

to the above-mentioned address. You will then be sent a list of available files. To retrieve one of these, the message:

send <filename>

(where <filename> is your choice) should be sent. To leave the list, a similar procedure is recommended; send:

unsubscribe se-list

to **maiser@pcmail.uni-trier.de** (as with all the above commands - be sure not to send such requests to SE-LIST itself, because this will send the message to all members of the list).

If there are any problems, e-mail the first author using the address **bb@uni-trier.de**.

6. Acknowledgements

We wish to thank the members of the University of Trier Computer Centre for their assistance in setting up SE-LIST. In particular, thanks to Klaus Schmidt (**root@uni-trier.de**) for acting as the system administrator for the list. But mainly, we wish to thank all SE-LIST members. Without them, nothing would be discussed.

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THE INFLUENCE OF UNITARY TILLAGE ENERGY UPON THE MECHANICAL RESISTANCE OF THE AGGREGATE STRUCTURE OF LIGHT SOIL

The objective of the research reported in this article was to evaluate the impact of tillage energy transferred into the soil by tractor wheels and working parts of machine and agricultural implements on the mechanical stability of soil aggregates. This energy is called unitary tillage energy.

We assumed that during cultivation at a low level of soil moisture two separate processes take place simultaneously. The first one results in the crushing of some of the aggregates and in the formation of a new structural configuration in the cultivated layer. The other process causes a reduction in the mechanical stability of those aggregates that do not break during tillage.

The research was carried out on two Polish soils of morainic origin, containing 54% and 62% sand respectively. They are cultivated intensively and relatively often. The average annual input of tillage energy ranges from 21.51 to 44.57 kJ/m^2 (Krysztofiak at al., 1993).

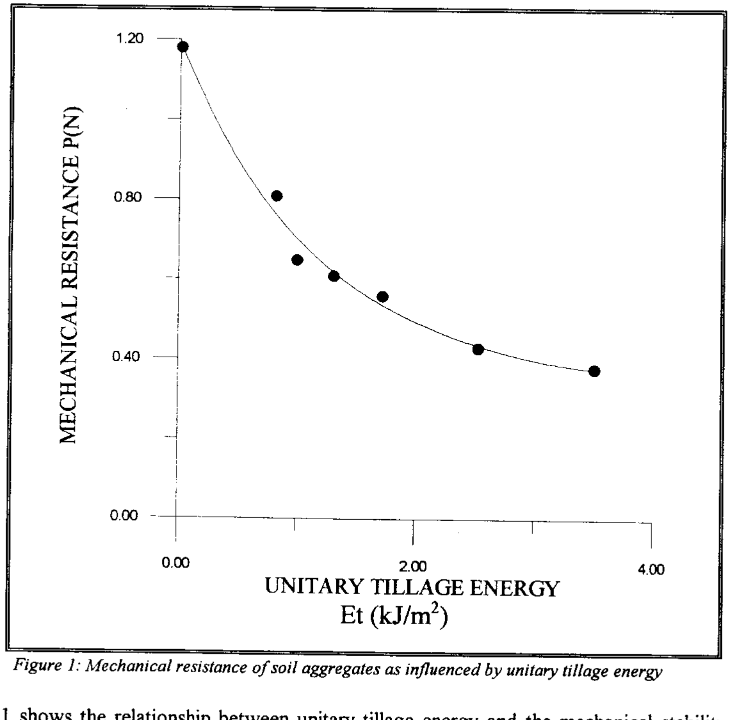

Figure 1: Mechanical resistance of soil aggregates as influenced by unitary tillage energy

Figure 1 shows the relationship between unitary tillage energy and the mechanical stability of dry aggregates (soil 1) of 2.0-3.15 mm in diameter. Field studies were carried out at the Crop Growing Station in Wierzenica (26 km east of Poznañ) in August 1993. Soil samples were collected from the cultivated layer at a depth of 0-10 cm. The experiments were performed with the assistance of a tractor equipped with a board-computer (recording wheel slip and velocity) and working with different agricultural implements and machines. Soil samples were gathered separately from plots compacted by tractor wheels, from cultivated plots and from non cultivated (control) plots. To determine the unitary tillage energy input, the STAPOD program was written based on the algorithm of Hagen et al. (in press). This program takes into account the tillage speed, the tractor wheel slide, the stability of the tractor implement set, the type of the implement, the tillage depth and the impact of the above factors on the amount of energy transferred to the soil.

Laboratory tests on the mechanical stability of single dry aggregates (2.0-3.5 mm in diameter) were conducted at the Agricultural University of Poznañ. The initial crushing force was recorded with the INSTRON 1140 measuring apparatus. The results indicate a close correlation between the unitary tillage energy and the mechanical stability of soil aggregates. An increase in tillage energy results in a reduction in the initial crushing force value needed to break the aggregates. The aggregates collected from the control plot (non-cultivated) disintegrated under the action an average crushing force an about 1.16 N, while after cultivation with a harrow the artificial crushing force was reduced to 0.38 N. This shows that the mechanical tillage of light sandy soils affects not only soil aggregate structure, but also the mechanical stability and in this way the abrasion resistance.

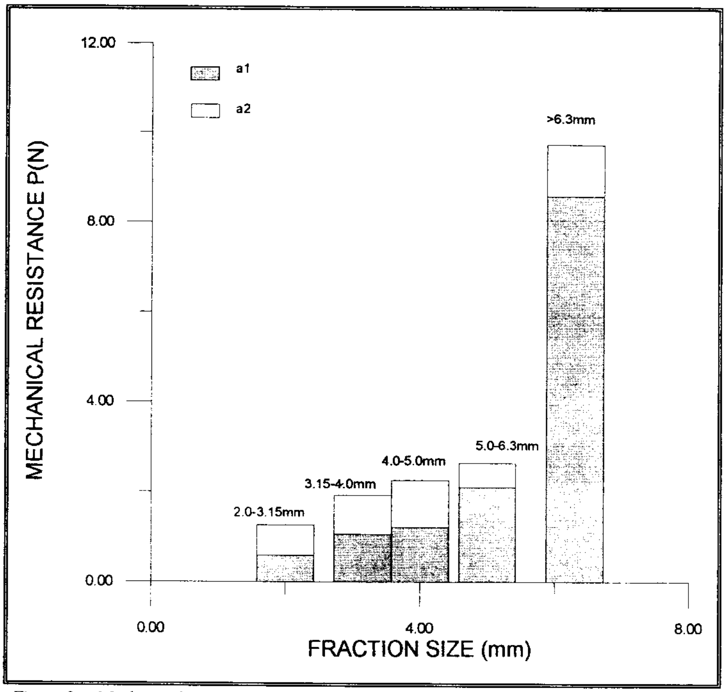

Figure 2: Mechanical resistance of soil aggregates as influenced by size
a1 : Natural aggregates, a2 : Artificial aggregates

Figure 2 illustrates the relationship between aggregate size and mechanical stability. The stability of natural aggregates collected from the soil cultivated with the harrow (Et = 1.3 kJ/m^2) was compared with the stability of artificial aggregates modeled and produced according to the method of Rzasa and Owczrzak (1983). The results confirmed previous observations by Skidmore and Power (1982) that the value of initial crushing force increases with aggregate size. The results also indicated that artificial, modeled aggregates are much more resistant than natural ones, even when the latter are gathered from non-cultivated soil. This arises from the fact that in natural conditions, particularly with frequent tillage, internal bonds of aggregates are not as strong as in the laboratory produced aggregates. Modeled artificial aggregates, however can be, used to assess the present physical state of natural aggregates. Such a reference system seems to be adequate to study soil structure, considering how many factors affect it and its stability.

The light eroded soils of Wielkopolska Region demonstrate a low level of aggregate structural stability. The main factor responsible for this is the particle size distribution, namely the low clay content. The mechanical stability of dry natural soil aggregates is decreased by tillage operations, namely by energy transferred to the soil during cultivation. The unitary tillage energy plays a great role in stimulating wind erosion processes in these soils.

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IRRIGATION EROSION OF SOILS IN THE NORTH CAUCASUS ECONOMIC REGION OF RUSSIA

The North Caucasus Economic Region occupies a leading place in the national economy of Russia, particularly with respect to agro-industry. Fertile soils and optimal climatic conditions of favourable temperature, solar radiation and length of daylight make this zone the main one for the production of grain, vegetables, fruit and rice. Most of these crops are grown on irrigated lands which cover some 2 million ha and represent 30 per cent of the whole irrigated area of Russia. the annual damage to these lands from all forms of erosion is estimated to cost about 700 billion roubles.

Natural and anthropomorphic factors are responsible for the water erosion of soils in both the irrigated and unirrigated lands. These factors interact to determine the evolution and dynamics of erosion. The natural environment has evolved over hundreds of years but is now being modified by human activity. Irrigation works regulate the slope of the fields, alter the strength properties, seepage and waterholding capacity of the soils, affect the quality of the rain and the hydraulics of open channel flows, and influence the agricultural crops grown on the land.

The application and management of irrigation technology in the North Caucasus has had catastrophic effects and caused much damage to agricultural fields. Furrow irrigation, using non-standard irrigation rates, has resulted in erosion rates of 150-300 tonnes of topsoil per ha. Under sprinkler irrigation, soil losses and runoff considerably exceed permissible limits as a result of generation of overland flow and rill flow, changes in the microrelief of fields, and changes in the infiltration capacity, micro- and macrostructure and texture of the topsoil. Open channel flow in perennial or annual irrigation canals damages agricultural fields. Soil losses per meter of channel length are between 0.01 and 0.10 m^3 while the total length of such canals in the North Caucasus irrigation zone is 250.000 - 350.000 km.

Based on the interaction of natural processes and anthropomorphic activity, a classification of erosion types related to irrigation systems is proposed. Rill erosion is associated with land under surface (flood) irrigation; raindrop, rill and sheet erosion occur with sprinkler irrigation; and channel erosion takes place in the irrigation canals. The approach allows an evalution of the negative effects and the after-effects of each erosion type.

A distinctive feature of the impact of erosion on the irrigated lands is that human factors (characteristics of the irrigation sprays and flows) exceed the natural ones (especially soils) in importance. In general, under furrow, sprinkler and flood irrigation, erosion occurs where the soil and geographic environment characteristics give rise to high erosion risk and low water seepage. These conditions are enhanced by the parameters of the irrigation sprays and natural rain. To ensure protection of the irrigated environment, the main task is to establish reliable indexes of soil stability. The principles of irrigation design must be developed on the basis of permissible values of the indexes.

When evaluating the effect of irrigation on erosion, the individual and combined impact of the controlling factors should be considered. For chernozems and chestnut soils, this means determing the areas below the critical slope at which soils remain stable; areas of slopes at which erosion can start; and areas with mass erosion loss of soil. Table 1 shows that more than half on the 2 million ha of irrigated lands are located on dangerous slopes, including 40 per cent of the lands with slope between 0.01 and 0.02 where irrigation must be implemented only with erosion protection measures. More than 1/7 of the lands are on slopes of 0.03 or higher where irrigation without erosion control is quite unacceptable.

Table 1: Correlation of erosion-dangerous areas in irrigated zone of the North Caucasus part of Russia

Region, territory, republic	Main soils	Irregated area (ha)	Slopes	Area on slopes (%)	Critical slopes*
Rostov region	chernozem and chestnut	460.000	0.01 0.01-0.02 0.02	16.01 14.02	0.023 0.022
Krasnodar territory	chernozem mainly	462.000	0.01 0.01-0.02 0.02	78.50 16.15 5.35	0.023 0.025
Stavropol territory	chernozem and chestnut	400.000	0.01 0.01-0.02 0.02	64.00 30.00 5.90	0.025 -0.022
Chechen and Ingush republics	chestnut and chernozem	176.090	0.01 0.01-0.02 0.02	36.45 48.53 15.02	0.022- -0.025
Dagestan republic	chestnut, alluvial meadow	292.600	0.01 0.01-0.02 0.02	38.57 14.55 46.88	0.022- -0.029
Kabardino-Balkarian republic	chestnut, chernozem, meadow chernozem	115.000	0.01 0.01-0.02 0.02	45.65 44.33 10.02	0.022- -0.029
North Ossetian republic	meadow chernozem, chestnut	63.000	0.01 0.01-0.02 0.02	21.64 25.68 2.68	0.029- -0.021

* - Critical slope corresponds to the erosion of inadmissible degree under sprinkling. For the surface irrigation the critical slope is two times less than the given one.

Regarding the erosive effects of sprinkler irrigation, land can be classified into areas which are erosion-safe, and areas where irrigation is, in turn, admissible, dangerous and catastrophic. The classes take into account the velocity of water flow on the soil which represents the derivative of the land slope and the size of the spray nozzle. An index of soil stability is based on the acceptable soil loss resulting in ecological equilibrium. For all soil types in the zone, depending upon their geographical location, biological and cultivated state (virgin soil, arable land, fall plowed land, wild land), the criteria for acceptable soil loss has been substantiated and permissible flow velocities have been calculated commensurate with a steady state condition.

The most important aspects of the interaction between soil and water under sprinkler irrigation are the stability of the soil structure when saturated and under the percussive impact of the spray drops, the infiltration capacity of the soil and the energy of the artificial rain. These aspects depend on the type and class of sprinklers, their design features and the irrigation technology.

The author's research is concerned with the quantitive evalution of the dynamics of irrigation systems, developing indexes and equations for forecasting their impacts. The research has proved that the generation of runoff under sprinkler systems is mainly a result of imperfections in irrigation design and technique. Such imperfections arise from the absence of reliable quantitative criteria for calculating permissible runoff and from differences between the processes of infiltration under sprinkler irrigation and those determined by standard methods. Infiltration under sprinklers has its own characteristics which differ from the conventional situation under constant flooding and these must be taken into account in an environmentally-friendly approach to irrigation.

The author has developed methods for determining directly the seepage of water into the soil under sprinkler irrigation and has substantiated quantitative indexes for acceptable runoff to protect the environment and conserve resources. Three alternative approaches are possible. One makes provision for choosing irrigation elements on the basis of standard calculations. The second is purely ecological and provides for the minimum runoff, conservation of the topsoil and maintenance of soil fertility. Criteria have been substantiated and the calculation methods developed for this case. The third case is for an intensive approach to the farming system which combines ecological and economic considerations; it makes provision for the additional measures and expenditures required for reducing runoff from the higher intensity of technology, including irrigation. For the theoretical and technological realization of the last alternative, a complex system of measures for preventing and averting erosion of the soil during design, construction and maintenance of irrigation works is substantiated.

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MACHINERY-INDUCED SUBSOIL COMPACTION IS A SERIOUS SOIL CONSERVATION ISSUE

Introduction

As soil scientists we have the responsibility to see that human activities do not cause permanent soil deterioration. Erosion, salinisation, acidification and pollution are already recognized by the public as serious problems. Now it is time to draw attention also to soil structure deterioration and particularly to subsoil compaction by vehicles with high axle loads, which poses a risk of causing permanent degradation of the subsoils.

Agricultural and forestry machines are gradually becoming heavier, and axle loads as high as 30 Mg can already be found. To avoid unacceptable subsoil compaction, action must be taken rapidly. In the short term, plough layer compaction is more important than subsoil compaction and can be caused even by rather light machines. Plough layer compaction, however, will generally be alleviated within a few years, whereas deep subsoil compaction caused by vehicles with high axle loads tends to be permanent and cumulative. Compaction affects virtually all soil properties and processes, physical as well as chemical and biological, and may dramatically impair normal soil functions. Though compaction sometimes has positive effects, its effects are usually negative.

The impact of heavy vehicles on subsoil properties and crop growth has been studied in several countries. Some studies have been coordinated by a working group within the International Soil Tillage Research Organization (ISTRO) with members from seven countries in freeze/thaw areas of Europe and North America. The members of the group established long-term field experiments with common treatments in their respective countries. Most of these have now been completed and the results were recently published in a special issue of „Soil and Tillage Research" (Håkansson, 1994). This contribution is mainly based on this issue.

Machinery-induced subsoil compaction, incidence and persistence

Predictions and measurements of stress distributions under loaded wheels show that mechanical stresses penetrate deeper when wheel/axle loads increase. Accordingly, measurements of various soil properties such as soil deformation, bulk density, porosity, penetration restistance and fluid conductivity, show that high axle-load traffic actually causes deep soil compaction. When using agricultural machines with traditional wheel equipment, the incidence of compaction in the plough layer is mainly determined by the ground contact pressure (which is closely related to tyre inflation pressure), whereas compaction of deep subsoil layers is largely determined by the wheel/axle load. In the upper part of the subsoil, ground contact pressure and axle load may be equally important, and thus, in this layer, low-pressure tyres can mitigate the effects of machinery traffic. Vehicular traffic on moist, arable soils typically causes significant compaction to a depth of about 30 cm at an axle load of 4 Mg, 40 cm at 6 Mg, 50 cm at 10 Mg, and 60 cm or deeper when the load exceeds 15 Mg.

Repeated traffic increases the effects. Tractor wheels running in the open furrow during mouldboard ploughing cause problems even when the axle load is low.

Various processes such as wetting/drying, freezing/thawing, biological activity and tillage contribute to the alleviation of soil compaction. Generally these processes alleviate plough layer compaction within a few years, but their influences decrease rapidly with depth, and therefore, subsoil compaction persists for decades. Thus, for example, in Australian forest soils, compaction still persisted 50 years after traffic. In Scandinavia, very dense basal morainic till soils may be found from a depth of only 50 cm. Geologists attribute their high density to intensive loading by the heavy ice cover during the latest glaciation. This suggests that compaction at depths of 50 cm persists for thousands of years. With a more normal human time-scale, compaction may be regarded as permanent already from a depth of 40 cm, and in coarse-textured soils or in regions without freezing maybe even shallower. However, some evidence of a slow alleviation of compaction in the 25-35 cm layer in clay or loam soils in freeze/thaw areas has also been presented.

Crop response to subsoil compaction

In the international series of experiments, traffic was applied by vehicles with an axle load of 10 Mg on one occasion when soil moisture content was close to field capacity. The surface of the experimental plots was uniformly exposed to tracks by the heavy vehicle up to four times. Subsequently, crop yields in these plots were compared with yields in untrafficked control plots for up to eleven years. Crop responses to the traffic varied considerably between sites and years, with a maximum yield decrease as high as 38%. After the third year, when it could be assumed that the compaction effects in the plough layer were alleviated, the mean crop yield reduction in the whole series of experiments after four passes by the heavy vehicle was 2,5%, and this remained constant throughout the experimental period. Thus, even the crop responses showed that subsoil compaction persists for decades. The crop yield reduction was approximately proportional to the traffic intensity, and it may be feared that the yield will continue to decrease up to a very high traffic intensity.

No rules could be derived concerning the sensitivity of subsoils with different textures to compaction. So far, soils of all types must be regarded as sensitive, but more information is required on effects in various soils. The climate is also of importance, since the drier it is, the longer the periods during the year when heavy traffic does not cause excessive compaction. In some of the experiments, traffic with axle loads of 18-20 Mg was also applied. This increased subsoil compaction and reduced crop yields more than a load of 10 Mg per axle.

Before the experiments were initiated, most of the sites had been trafficked by normal farm vehicles and they had been repeatedly mouldboard ploughed with tractors running in the open furrows. Therfore, the upper part of the subsoil was precompacted to some extent, which probably reduced the effects of the experimental traffic accordingly.

Recently, the author made an effort to apply the crop yield results from the experiments on prevailing machinery systems in Swedish agriculture. This indicated that permanent yield reductions at present often accumulate at a rate of 1% per 8-10 years. If axle loads continue to increase, this rate will rapidly increase.

Possibilities to ameliorate compacted subsoils by mechanical loosening

In large areas of agricultural land, the upper part of the subsoil has already been compacted by high axle load traffic or by pressure and slip by tractor wheels in the open furrow when ploughing. Therefore, numerous techniques for subsoil loosening have been developed. However, such operations can seldom completely ameliorate subsoil compaction, at least not in deeper layers. Furthermore, subsoiling temporarily destabilises soil structure. Consequently, a prerequisite for a persistent effect is that subsequent loading is substantially reduced until the structure has stabilized. A rapid recompaction may otherwise occur. Therefore, it is better to avoid over-compaction of the subsoil by protecting it against mechanical overloading than to loosen it periodically.

Counter-measures

It would be desirable to eliminate all random field traffic by vehicles with high axle loads. However, development of alternative techniques is difficult and time-consuming, if it is possible at all. In the foreseeable future, therefore, the machinery will be of the existing type, but to avoid unacceptable subsoil compaction the design and use of the heaviest units must be modified. Sufficiently low axle-load limits would be a safe solution. This implies that heavy machines must be equipped with an adequate number of axles and wheels. However, since low-pressure agricultural tyres are now available even for high loads, combinations of axle-load and ground-pressure limits may be more economical. Furthermore, subsoil compaction can be reduced to some extent by avoiding traffic under moist conditions, by using rubber-belt tractors, controlled traffic or gantry systems, and by avoiding traffic by tractor wheels in the open furrow when mouldboard ploughing. Periodic subsoil loosening may set an upper limit to the negative effects of subsoil compaction, but this is expensive.

Tentative standards for maximum permissible stresses in the soils or recommendations of axle load limits have already been worked out in some countries. As soon as possible, guidelines for permanent limits of mechanical stresses in the soils should be developed in an international joint effort. Such limits must be bases on general soil and climatic conditions in suitable regions, and be set with regard rto the conditions occurring when various machines are used.

Whenever possible, information on soil compaction effects should be supplied to farmers and machinery manufacturers in economic terms. „Compaction costs" are sometimes very high, and therefore, estimates of these costs will stimulate activities in devising alternative-techniques. However, in contrast to surface layer compaction, subsoil compaction is not a purely economic problem. Since it may reduce food supply for future generations, it is also an ethical problem, and a responsibility of Society.

Future activities

Available information on subsoil compaction is not yet sufficiently detailed, and more research is needed. Nevertheless, it enables us to conclude that increasing machinery weights sooner or later will lead to unacceptable consequences for long-term soil productivity, resource economy and environental effects of agriculture. My personal interpretation is that this situation has already been reached in many cases. Subsoil compaction is at least a potential problem everywhere in the world, and it should be studied worldwide. It may strongly reduce water infiltration, and may be most serious in regions with runoff and erosion problems. In regions where field operations are not yet mechanized, experiments should preferably be carried out before major investments in improper machines are made.

Society should consider the establishment of limits for mechanical stresses in the subsoil. An international effort to establish guidelines for such limits is desirable. An international workshop for discussions of this issue between scientists concerned and organizations working with protection of natural resources should be arranged. Information on this problem should rapidly be spread to the public.

Reference

Håkansson, I., 1994 (editor). Special issue: subsoil compaction by high axle load traffic. Soil Tillage Res., 29: 105-306.

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AIM - ANNOUNCEMENTS, INFORMATION, MEETINGS

ANNOUNCEMENTS

EUROPEAN SOCIETY FOR SOIL CONSERVATION
Second International Congress
DEVELOPMENT AND IMPLEMENTATION OF SOIL CONSERVATION STRATEGIES FOR SUSTAINABLE LAND USE

Technische Universität München Weihenstephan (Germany), 1-7 September 1996

2nd Circular

Theme

In spite of a strong public awareness of environmental problems, soil conservation is still not realized in politics, administration and practical soil use. Old threats such as soil erosion continue to challenge while new problems, such as the emission of atmospheric trace geases, emerge. Knowledge about the processes involved and appropriate protection measures should be gathered and shared among all those, who are responsible for soil conservation to ensure sustainable soil use.

Sessions

The congress is composed of four sessions. Each session will begin with an invited keynote address.

Session 1: Soil compaction and structure deterioration.
Convener: M. Kutilek, Prague.

Session 2: Soil contamination (heavy metals, acidification, xenobiotics).
Convener: R. Prost, Versailles.

Session 3: Strategies to minimize soil erosion and ecological side-effects.
Convener: F.J.P.M. Kwaad, Amsterdam.

Session 4: Soil consumption (use of peat, loam etc., construction site losses).
Convener: R. Häberli, Berne.

Oral or poster presentations on these and other related topics are welcomed. The achievements of the Congress will be summarized in a publlic workshop on the last day. The ESSC conference will be followed by a conference of the International Soil Conservation Organization ISCO in Bonn (Germany). The ISCO conference will focus on the global instead of the European view. The delegates of the ESSC conference are encouraged to also attend the ISCO conference.

Abstracts

Abstracts of one page length (300 words maxium) for both oral and poster presentations should be sent to the Congress Treasurer by Dec. 31, 1995. Abstracts should include the title, author(s), institution address(es), and proposed session number. The abstract should be concise and cover the main points of the presentation. Abstracts should not include references, diagrams or drawings. A book of abstracts will be distributed to delegates upon registration.

Oral Presentation
Each Presentation will be allocated 20 minutes, including time for discussion. Keynote presentations will be allocated 30 minutes.

Poster Presentation
Posters will be displayed in the main hall. Time will be allowed for discussion of the poster presentations. Cork display boards are 150 cm high and 85 cm wide. Fixing material will be provided.

Congress Proceedings
Poster and oral presentations may be published in English in a special issue of *Soil Technology* after passing the usual reviewing process. Detailed guidlines for the preparation of the manuscripts are given in the inside cover of *Soil Technology* and can be obtained from *Elsevier*.
Three copies of the paper must be delivered to the Congress Secretary NOT LATER than at the congress. The authors are encouraged to include a floppy disc together with the paper copy of their manuscripts.

Pre-Congress Tour: Hallertau and Danube Valley, Sept. 1st
The price is DM 40 and includes transportation, lunch package and tour guide.

Mid-Congress Tour: Scheyern Experimental Farm, Sept. 4th
The price is DM 40 and includes transportation, guide, lunch and beverages.

Post-Conference Tour: Nationalpark Berchtesgarden, Sept. 6th-7th
The price is DM 185 and includes bus transfer, overnight stay in double rooms with shower incl. dinner and breakfast, ticket for the cable tram, lunch package and a tour guide. A maximum of 20 single rooms are available for an additional charge of 30,- DM.
Please confirm your trip not later than the 28th of February 1996. Maximum participants: 40.
This tour will end in Freising, where we arrive at about $19^{\circ\circ}$.

Location and Infrastructure Accomodation
The campus ("Weihenstephan"), 30 km NE of Munich, can be easily reached by plane (5 km to Munich International Airport), by train (1 km to the railway station in Freising) or by car (10 km to nearest freeway).
Temperature in early September ranges between 10 °C (night) and 20 °C (day). More than 10 mm of rain can be expected only once a fortnight.

Accomodation
A variety of accommodations is available in different class hotels in Freising (40 000 inhabitants), prices ranging from 70 to 200 DM (bed & breakfast). A list of hotels together with prices, telephone and FAX numbers will be distributed together with the congress guide (mailing in May 1996).

Visits
Several research institutions focusing on soil research are located in the Munich area:
- Bayrische Landesanstalt für Bodenkultur und Pflanzenbau (Bavarian Department of Soil Technology and Agronomy)
- Institut für Bodenökologie im Forschungszentrum für Umwelt und Gesundheit GSF (Institute of Soil Ecology at the reseach Center of Environment on Health)

- Institut für Bodenkunde der Forstwissenschaftlichen Fakultät (Department of Soil Science at the Faculty of Forest Sciences)
- Bayrische Geologisches Landesamt (Bavarian Geological & Soil Survey)

Contacts can be made with these institutions upon request in advance.

Congress Banquet

Evening dinner with Bavarian specialities an Bavarian folk music at Schloß Hohenkammer, a castle originating from the 15[th] century. Price: DM 80.

Registration Fees

Members of ESSC: .... DM 180
Non-members.......... DM 200
Students.......... DM 100

These fees include lunch, congress abstracts, and congress foulders. The congress tours and the social event will be charged seperately. The payments must be made exclusively in German Marks (DM) by March 31, 1996 by remitting the amount to Account No. 400 100 1, Code word 'ESSC-96; AST-Nr. 820 296-2' with the Bayrische Vereinsbank, Freising, Germany or by sending a collection-only cheque made payable to 'Lehrstuhl für Bodenkunde TUM'.

Cancellation

In case of cancellation later than March 31, 1996, no registration fees will be refunded. Befor this closing date, 75% will be refunded.

Letter of invitation

A letter of invitation will be sent upon request.

Accompaning Persons

Visits to places of interst in Munich or to some of the Bavarian castles can be arranged when requested in advance. A theatre performance in Munich may also be considered.

Deadlines

Please complete and return the attached form. Deadlines are:

- Registration for presentation.......... 31 Dec. 1995
- Notification about acceptance.......... 28 Feb. 1996
- Registration for post-congress tour.......... 28 Feb. 1996
- Registration for congress and tours.......... 1 April 1996
- Mailing of congress guide.......... 31 March 1996
- Submitting full papers.......... at the Congress.

Organizing Committee

Chairman:	Prof. Dr. U. Schwertmann
Secretary and Organizer:	PD Dr. K. Auerswald
Treasurer:	Dr. H.H. Becher
Conference Tour Organizers:	Mr. M. Kainz, Dr. H. Stanjek, Prof. Dr. J. Pfadenhauer.

REGISTRATION FORM

Title (Mr./Ms./Mrs. + Prof./Dr. or the like):

Surname: First name:

ESSC-Member (yes/no):

Institution:

Road or P.O.Box:

Place incl. CIP:

State:

Accompanying persons:

1 Surname: First name:

2 Surname: First name:

3 Surname: First name:

First Author (y/n): Presentation(s): Oral / Poster (o/p):

Title of Paper:

Co-author Name(s):

Participating in Tours etc. (y/n):

Pre-Tour (y/n): Pers.:

Mid-Tour (y/n): Pers.:

Post-Tour (y/n): Pers.:

Dinner (y/n): Pers.:

Fees (DM):

	Member	acc.Pers.	Non-Member	acc.Pers.
Conference:	180.00	0.00	200.00	0.00
Pre-Tour:	40.00	40.00	50.00	50.00
Mid-Tour:	40.00	40.00	50.00	50.00
Post-Tour:	185.00	185.00	200.00	200.00
Dinner:	80.00	80.00	80.00	80.00

Total:

!! Please return to:

Dr.H.H.BECHER
Lehrstuhl für Bodenkunde
Technische Universität München
Weihenstephan 1

D-85350 Freising
Germany

AIMS OF THE SOCIETY

The ESSC is an interdisciplinary, non-political association, which is dedicated to investigating and realizing soil conservation in Europe.

The ESSC pursues its aims in the scientific, educational and applied sectors
- *by supporting investigations on soil degradation, soil erosion and soil conservation in Europe,*
- *by informing the public about major questions of soil conservation in Europe,*
- *by collaborating with institutions and persons involved in practical conservation work in Europe.*

The ESSC aims at co-ordinating the efforts of all parties involved in the above cited subjects: research institutions; teachers and students of geo-sciences, agriculture and ecology; farmers; agricultural planning and advisory boards; industries and governmental institutions.

ZWECK DER VEREINIGUNG

Die ESSC ist eine interdisziplinäre, nicht politische Vereinigung. Ihr Ziel ist die Erforschung und Durchführung des Schutzes der Böden in Europa.

Die ESSC verfolgt dieses Ziel auf wissenschaftlichem, erzieherischem und angewandtem Gebiet
- durch Unterstützung der Forschung auf den Gebieten der Boden-Degradierung, der Bodenerosion und des Bodenschutzes in Europa,
- durch Information der Öffentlichkeit über wichtige Fragen des Bodenschutzes in Europa,
- durch Zusammenarbeit mit Institutionen und Personen, die an der Praxis des Bodenschutzes in Europa beteiligt sind.

Die ESSC will alle Personen und Institutionen zusammenführen, die sich für die genannten Ziele einsetzen: Forschungsinstitutionen, Lehrer und Studenten der Geowissenschaften, der Landwirtschaftswissenschaften und der Ökologie, Bauern, landwirtschaftliche Planungs- und Beratungsstellen, Industrieunternehmen und Einrichtungen der öffentlichen Hand.

BUTS DE L'ASSOCIATION

L'ESSC est une association interdisciplinaire et non politique. Le but de l'association est la recherche et les réalisations concernant la conservation du sol en Europe.

L'ESSC poursuit cette finalité dans les domaines de la recherche scientifique, de l'éducation et de l'application:
- *en encourageant la recherche sur la dégradation, l'érosion et la conservation du sol en Europe,*
- *en informant le public des problèmes majeurs de la conservation du sol en Europe;*
- *par la collaboration avec des institutions et des personnes impliquées dans la pratique de la conservation du sol en Europe.*

L'ESSC souhaite favoriser la collaboration de toutes les personnes et institutions poursuivant les buts définis ci-dessus, en particulier: institutions de recherche, professeurs et étudiants en géosciences, des agriculteurs, des institutions de planification et des conseil agricole, de l'industrie, et des institutions gouvernementales.

OBJETIVOS DE LA SOCIEDAD

La ESSC es una asociación interdisciplinar, no-política, dedicada a la investigación y a la realización de acciones orientadas a la conservación del suelo en Europa.

La ESSC persigue sus objetivos en los sectores científicos, educacionales y aplicados, en el ámbito europeo:
- promocionando la investigación sobre degradación, erosión y conservación de suelos;
- informando al público sobre los principales aspectos de conservación de suelos;
- colaborando con instituciones y personas implicadas en la práctica de la conservación de suelos.

La ESSC aspira a coordinar los esfuerzos, en los temas arriba mencionados, de todas las partes implicadas: centros de investigación, profesores y estudiantes de geo-ciencias, agricultura, selvicultura y ecología, agricultores, servicios de extensión agraria, industrias e instituciones gubernamentales.

YES, I WANT TO GET MEMBER OF THE ESSC !

(Please write in capital letters or with typewriter)

LAST NAME ....

FIRST NAME .... TITLE ....

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Date .... Signature ....

YES, I WANT TO PAY MY ESSC-MEMBERSHIP CONTRIBUTION !

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I am ☐ a new member of the ESSC ☐ already member of the ESSC

The ESSC membership contribution is 50,00 DM per year, or 140 DM per three years (1996-1998). The period of free membership for ESSC-members in the former "East European countries" has been extended to cover also 1996.

☐ I want to pay my membership contribution for
- ☐ 1996 (50,00 DM)
- ☐ 1996-1998 (140 DM)
- ☐ .... (................ DM)

☐ I don´t know, whether I have to pay outstanding membership contributions. Please sent me an invoice.

I want to pay the ESSC membership contribution

☐ with enclosed cheque

☐ bank transfer (bank account: Dr. G. Richter, ESSC; Deutsche Bank Trier; Konto-Nr. 501 932, BLZ 585 700 48)

☐ by mail-order with my credit card (The only thing I have to do is to fullfill the following mail-order form)

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I agree to pay my ESSC membership contribution for the year/years .... by credit card.

☐ EUROCARD/MASTERCARD ☐ AMERCAN EXPRESS CARD ☐ VISACARD

Card number .... Expiry ....

Amount ....DM

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Please send the form to the ESSC Secretary, Prof. Dr. G. Richter, Universität Trier, D-54286 Trier/Germany