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NEW OPPORTUNITIES FOR SELF-SUFFICIENCY WITH PERMACULTURE ALSO ON PSEUDOGLEY SOILS

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ABSTRACT

New opportunities for self-sufficiency with permaculture also on pseudogley soils

Among the soils, which until now have not been involved in food production are pseudogleys. These are compacted soils that are not suitable for treatment without the use of permaculture. In field study we monitored selected areas of soils and found a significant effect of permaculture in pseudogleys. We have found that all physical properties of the soils are improved, in particular the structure, consistency, aeration, organic matter content and retention capacity. Pseudogleys are very common type of soils at the turn of hilly areas in the plains which are densely populated areas, so they can be an important natural resource for food production.

KEY WORDS
soil geography, pseudogley, permaculture, self sufficiency, soil properties.

1.Introduction

Pseudogley soils are at FAO Unesco classification assigned to Class hydromorphic soils with the most common sequence of horizons A-Bg-C (Repe, B. 2010, 135). Agricultural profession ranks among the medium to lower quality to an otherwise favorable terrain (foot slope). Their main drawback for agricultural use is extremely bad air water regime. In rainy periods because of hard permeable Bg horizon water lags on the soil surface. In dry periods, due to compacted Bg horizon topsoil dries out strongly and cracks. Crop planting is therefore strongly affected by the drought.

Periods with favorable abilities of pseudogleys soils are short. Many have abandoned agricultural use in the pseudogleys because of poor physical properties, in spite of ecosystem benefits that these soils have. Pseudogleys retain water well, as they are rich in clay and silt. In the last decade we can notice the increasing trend for self-sufficiency by using permaculture, so we can use pseudogleys soils as additional natural source of food as well. Permaculture is more than a land-use planning, as it is a combination of settlement and food production, water supply, energy, wastewater treatment and coexistence with animals (Whitefield, P. 2012, 12). Many places are still preserved natural purification systems (vegetation belts, sand filters and phytoremediation plants in puddles) and these maintain the balance of nature.

2. Review of Literature

The word permaculture or "permanent agriculture" is known as "sustainable farming", i.e. management in harmony with nature, which is based on the natural cycle and ecosystems (Laughton, R. 2013, 4). Permaculture is the conscious design and maintenance of agricultural productive systems which have the diversity, stability and resilience of natural ecosystems (Mollison, B. 1994, 15).

Permaculture varies from other soil management practices according to the conscious use of patterns and ideas that have been observed in nature and do not require large inputs. Permaculture can be understood as an art of the possible (Bell, G. 2010, 10).

It means, we use as many natural materials and things that nature offers us in itself. The aim of permaculture is to create an ecosystem environment that is self-sustaining. The systems of permaculture must maintain itself as far as possible, meaning that it does not need a continuous introduction of foreign energy to operate. When the system is up, the man stays out as little as possible, since such systems then work on their own (Januš, B. 2013, 34).

Mulching has long been used to retain moisture in soils and for improvement of the physical properties of the soils. Mulch is a layer of plant residue or other materials which are coated on the ground around the plants. Mulching is designed to prevent the growth of weeds and retaining moisture in the soil. Mulch also has other beneficial effects it prevents erosion and regulates the temperature in the soil because of shading. With the decommissioning of mulch from organic materials we tend to improve soil fertility (Kodeks ravnanja, 2013, 22).

Mulch has so many positive attributes such as reducing evaporation of water from the surface of the soil, the plants need 25 – 50 % less water, prevent the soil compaction, soil moisture is stabilized (no large fluctuations), inhibits the growth of weeds, reduces the temperature of the soil, prevents erosion and improve the aesthetic appearance of the soil. Mulch from timber or bark can be used around trees, shrubs and perennials. This mulch slowly decomposes and reduces soil compaction. In the mulches from bark is part of the nitrogen from the soil used for mulch decomposition by microorganisms.

Straw is used as mulch in the spring; it stores a lot of heat radiated by the earth, which is in the early spring months still cold. Mulch from bark is used in a thickness of 2-10 cm. The thickness between 7 and 10 cm well inhibits the growth of most of the weeds. Soils that are heavily compacted or contain a lot of clay, can by the use of mulch minimize evaporation of water and causes increased soil moisture, which causes roots to rot in sensitive plant species. Under organic mulch the soil temperature is lower, this is particularly important when the temperatures are very high (above 30 degrees). Organic mulch is not suitable for areas with very cold air conditioning and early spring planting because the soils are still cold (Šink, N. 2013, 213).

For warming of the cold soils are very important solar radiation and high air temperatures. If the grounds are covered with mulch this prevents and slows down the development of the plant. Mulch prevents evaporation of the water and the growth of weeds. With the mulching is soil protected against harsh weather conditions such as heavy summer storms, strong winds, hail, and the sun rays. Extreme weather splinter soil, so they become hard and demanding for working. In compacted soils is difficult to grow plant roots and also edafon has difficulties to develop there, which results in the reduction of ecosystem services (fertility).

Additional mulch is also important because it slows down the growth of weeds, so there is less weeding and jamming plant growth during the growing cycle. Mulch can also be used as a fertilizer and protection against external influences and potential pests. Mulch provides food to many ground-organisms and micro-organisms and improves the mineral composition of the soil.

Vegetable mulch of hay partially retards the growth of plants in the first two weeks or. in the first month of growth. But after one month, these differences are not visible anymore (Ban, D., Sinčić Pulić, B., Oplanič, M., Borošić, J., Žnidarčič, D. 2009, 358). Humus in the soils performs important functions, namely keeping the stability of the soil and retains moisture, reduces the leaching of nutrients from the upper profile of the soil and improves soil structure, which is essential for plant growth. Availability of air and water in the roots is essential for fertile soil. Only that is associated with the type soil.

Through the automorph soil the water smoothly flows in hydromorph lags in-between and prevents the normal development of the profile. An example is pseudogley where the water is retained in the B horizon in the increased level of the clay, which is washed from the A horizon in Bg1 and Bg2.

For the mulch we use either dried or semi-dried biomass, which does not contain any seeds. The most often we use hay, straw and dried grass lawns. Special mulches are from the nettles, pulses, legumes and comfrey and are intended for fertilizing soil. Many plants are sensitive to drought, so the growth performance significantly affects the moisture content.

In September 2011, we started taking soil samples from the pseudogleys field in Dole at Poljčane. We have taken two samples soil, namely in two places at the field. At that time the field wasn't treated as permaculture, but was occasionally deeply plowed. This processing method was previously used for at least 30 years. The field was often left empty, because the work was demanding and the yield was low.

For research purposes, we immediately started using hay mulch, so we covered the field with dry hay in a thickness of 10 cm during the winter and the fields were not plowed. In the spring of 2012, we used the system of permaculture and edited it from arable surfaces into raised beads. Over the years we have covered the ground with mulch, hay in addition, but we also used straw and the autumn leaves. Such a process of covering was used in 2012 and in 2013. We never watered crops.

Sampling: 2011 We took a sample of 1 from Ap horizon in the depths 0-15 cm (sample was mixed) and sample 2 from second part of the cultivated fields also in the depth 0-15 cm. we measured the following soil properties: color, moisture, consistency, field water capacity FWC, the amount of the skeleton, the size of the skeleton structure, texture, calcium carbonate, pH and organic matter content. The same procedure was repeated in September 2013, at two corresponding positions. With this research we wanted to determine how the use of permaculture has changed the properties of soil from September 2011 to

September 2013. Soil analysis was carried out according to international ISO standards for soil (http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=54328).

4. Results

Characteristics of the pseudogley soil in Dole at Poljčane

In an area of research pseudogley soils dominate. Gray and brown color in the profile pseudogleys exchange, depending on the duration of dry and wet periods. During oxidation brown color prevails, at the time of reduction becomes gray (Figure 1). Groundwater in these soils can not be reached, so there is no uniform gray horizon (Repe, B., 2010, 150). Water always flows in the profile from top to bottom. On the pseudogley grew oak sessile oak, in the past which were mostly grubbed up. For agricultural use this soils are not favorable because in the dry season are very solid in wet and spreadable. This natural properties have been the reason for the permaculture way of cultivation of soil on the learning polygon in Dole.

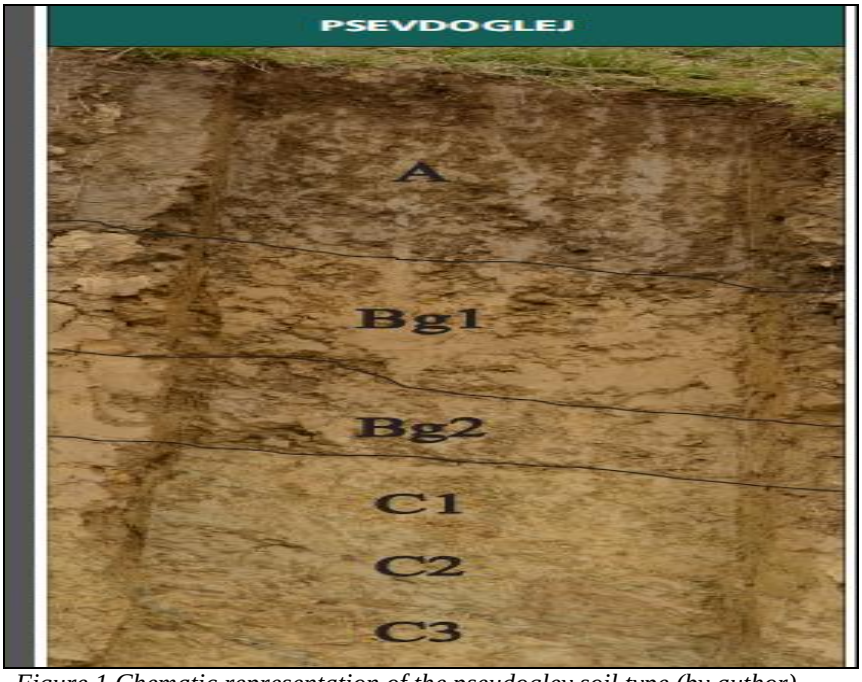

Figure 1.Chematic representation of the pseudogley soil type (by author)

Description of soil:
Soil type: pseudogleys planar, district, medium-deep
Pedogenetic factors: macro relief - valley bottom, lithological basis - fluvioglacial layers of clay and clay, agricultural use is primarily lawn, in the past two years, arable land with shallow plowing and effect.

Description of Horizons:

A horizon: 0-26 cm, friable, non-sticky, not-plastic, dry, silty loam, lumpy, humus, brown, medium number of roots medium (10% of the roots in the size of 2 mm), the biological activity of poor, earthworm tunnels very rare, no concrescere (concrecy), the soil is odorless, free of carbonates and the pH is 5.5, no skeleton.

Bg1: 26-45 cm: hard friable, non-sticky, not-plastic, dry, silt clay, loam, thick lumpy, poorly humus, gray-brown color, low number of roots low (less than 5% of the size of the roots greater than 2 mm), the biological activity is very poor, tunnels earthworms are not visible, concrescere (concrecy) of iron, soil smells like the earth, free of carbonates and the pH is 5.3, no skeleton.

Bg2: 45 - 56 cm: Very hard to crumbly, non-sticky, not-plastic, dry, silt clay, loam, very thick lumpy, non-humus, dark gray-brown color, no roots, it is not biologically active, concrescere (concrecy) of iron, soil smells like the earth, free of carbonates and the pH is 5.0, no skeleton. The average annual temperature research area is 9.5 degrees in the vegetation period starts at 15.5 degrees, the annual 1074 mm of precipitation falls. The annual potential evapotranspiration is 642 mm.

The results of measurements properties of the soil

In Table 1 contains data of the properties of the upper Ap horizon soil in a thickness of 15 cm. It can be seen that the two samples from a field have similar properties. The sample from the upper part of the field has 2% low humidity, and a smaller diameter of the no skeleton, the pattern on the bottom of the fields has several clay and lower pH. The measured properties of two sampling points from the field indicate that the soils are poor with organic matter to demonstrate occasional water retention (grayish color) and they are difficult to process because of the structure of lumpy and hard consistency. Therefore, we are at the end of September 2011 decided for transition to the permacultural processing.

For arable surfaces, it is important to reduce the lumpy and increased attrition with the addition of organic substances. Therefore, we rearranged soils the first

year into permaculture by lifted perches and wholesale (10 cm) covered with hay mulch. For two years we have been regularly using permacultural methods (most of it was in the beginning, and then the shaft support themselves).

Table 1.Soil without permaculture use September 2011

Color	Sample 1 gray - brown	Sample 2 gray - brown
Moisture content	17 %	19 %
Consistency	stiff	stiff
FWC mm	110	112
Amount of skeleton	2 %	2 %
Size of the skeleton	1- 4 mm	3 – 4 mm
Structure	lumpy	lumpy
Texture	SL	SCL
Calcium carbonate	1%	1 %
pH 7	6,10	5, 90
Organic matter	2 %	2,2 %

Legend: SL - silty loam, SCL - silty clay loam

In table 2 there are the data after two-years of using permacultural approaches, namely, mulches and lifted perches. After taking soil samples, we found significant differences. Soils, which were covered with mulch, were friable (such as moles earth). There were no lumps and were evenly moist. They were visibly darker in the upper of Ap horizon, because of addition of dolomite sand to increase the content of carbonates were visible skeletal fragments. The data show that the soils are darker, containing one third of moisture, are friable, FWC is high, proportion of skeleton decreased, the structure is lumpy, the texture is loam with less clay and higher Ca C03, pH 7, and organic matter content of 4.2 %.

Table 2.Soils with permaculture use, september 2013.

	Sample 1	Sample 2
Color	Brown dark	Brown dark
Moisture content	26 %	27 %
Consistency	crumbly	crumbly
FWC mm	141	147
The amount of the skeleton	3 %	2,7 %
Size of the skeleton	0 – 4 mm	0 – 4 mm
Structure	lumpy	lumpy
Texture	L	L
Calcium carbonate	2,5 %	2,7 %
pH 7	7	7
Organic matter	4 %	4,2 %

Legend: L – loam

5.Characteristics of soil properties with permacultural use

Comparison of soil samples in 2011 and 2013 shows a marked effect of permaculture in two years (Table 3). The darker color of the upper horizon after two years of permaculture is the result of weathered organic material. It is extremely important in the processes that occur in the soil, as well as good water retention and a source of energy for soil micro-organisms (Zdruli, Jones, in Montanarella, 2004, 22). The transition of soil colors goes from gray to brown, and dark brown also shows that water does not stagnate in the Ap any more.

Table 3. The differences in the properties of the soil and the total gap in pseudogleys

	Sample 1	Sample 2
Color	Darker brown	Darker brown
Moisture content	+ 9 %	+ 8 %
Consistency	from the hard to crumbly	from the hard to crumbly
FWC mm	+ 30 mm	+ 25 mm
The amount of the skeleton	+ 1 %	+ 0,7 %
Size of the skeleton	- 1 mm	- 1 mm
Structure	from a lump into lumpy	from a lump into lumpy
Texture	Iz SL v L	Iz SCL v L
Calcium carbonate	+ 1,5 CaCO3	+ 1,7 CaCO3
pH 7	+ 0,9	+ 1,1
Organic matter	+2 %	+ 2 %

Legend: SL - silty loam, SCL - silty clay loam, L - loam

6. Discussion

An increased moisture content of the soils, on the one hand is a consequence of rainfall, which have been a few days prior to sampling, as well as the ability to trap the moisture in the soil. Soils that have organic matter have a greater ability to retain moisture. Moreover, by acting on the mechanical processes that take place in the soil, on the air content into soil, and the gas exchange therein. This affects the activity of microorganisms, root respiration, and the chemical state of the soil. The consistency of soils has changed from hard into crumbly and without physical cultivation soils. Continual coverage of the soils with organic matter has enabled the voices of microorganisms and soil animals that have improved the consistency of the soil.

Skeleton in the soil is the result of mechanical weathering of parent basis, which has a similar mineral composition as the home base. Increased share in soils in 2013 is due to the addition of dolomitic sand due to the increasing

proportion of carbonates and, consequently, raising soils pH values in your answer, because pseudogley soils are poor with nutrients. We detected changes in the texture of the soils, namely the share of silt.

Silt is the result of physical weathering of sedimentary alluvium in the Pleistocene and quite difficult to normal air entry system. Average sample soils containing at 45% of mineral substance and 25 % of water, 25% of air and 5 % of organic matter. Various forms of mineral particles, such as sand, silt and clay, affect the texture of the soil (Soil - a key resource for the EU, 2010).

The texture is the ratio between the individual, already listed fractions, which are located in the soil at different rates. Impact on air and water regime of soils and to the physical and mechanical properties such as compaction and loosens. In addition, also affects on the absorption capacity and the possibility of proliferation of roots through which plants absorb water, oxygen and nutrients. By reducing the proportion of silt and loam dominate with a balanced representation of fractions of sand, silt and clay, improved water-air-soils system.

Another indicator of the occurrence of soils was the calcium carbonate content in the soil. The latter affects the physical, chemical and biological properties of the soil, and in addition, it is also an indicator of the benefits thereof for processing. In 2011, there were very few of carbonates in the soil, so we have been adding over dolomite sand. Too high values of carbonates are also not suitable because they are blocking particular deprivation of phosphorus from the soil which plants urgently need. The permaculture can positively balance proportion of carbonates, which indirectly affect the reaction of the soil.

The pH value is an indication of the concentration of hydrogen ions in the soil, wherein the relationship between the pH and the hydrogen ions which are inverse and logarithmic. Soil pH varies widely, and by the value 2, wherein the soils are very acidic and the value 12, which reflects the alkalinity of soils. When soil is cultivated pH is desired to move between 6 and 7 (Ellis, S. and Mellor, A. 1995, 40). pH may be in the soil increased by the addition of carbonate sand and compost, reduce it by the addition of silica sand and forest soils. The ideal pH is 7, because most of the plants in this reaction can smoothly withdraw all of the nutrients from the soils. The favorable reaction of soils is also important for natural cleaning of soil. With bioremediation and natural soil rehabilitation we can accelerate the pedogenetic processes (Okolo, J.C., Amadi, E.N., Odu, C.T.I. 2005, 47), which have a positive impact on the formation and maturation of soil. Organic matter in the soil is considered an essential component of healthy soils, reducing it to the degradation. Permacultural beneficial effects are reflected in the fact that organic carbon in the soil supports its structure, as it improves the physical environment for roots to penetrate through the ground. Organic matter also absorbs and retains water.

Soil contains organic matter and has a better structure that improves water infiltration and reduces the susceptibility of soil to compaction, erosion and landslides.

Accessibility of air and water to the roots is essential for fertility. Only that it is associated with the type soil. Water through the automorphic soils smoothly flows in hydromorphic lags in between and prevents the normal development of the profile. An example is pseudogley where the water stays in the B horizon in the increased level of the clay, which is washed from the A horizon into Bg1 and Bg2. A very important factor in plant growth is pH optimum growth which was recorded in the neutral to slightly alkaline reaction (Nayak, S., Prasanna, R. 2007, 104).

7.The importance of mulches for soils

Using the mulch has a significant impact on the retention of moisture in the soil. The results of research show the importance of keeping mulches moisture in the soil. Analysis show that the moisture retained in the most of raised beds and on the surface and in depth. Pseudogley soils contain higher proportions of clay in Bg horizon which dries-out in the dry season, thus allowing penetration of warm and dry air in depth and add to the drying of soil. High perches contribute significantly to keeping moisture in the soil in depth, since the composition effect of high contents of organic matter helps to retain moisture in comparison to the field or meadow, which have no organic matter in the lower horizons (Posa, B., Fekete, Posa, A., Posa, P., Sallai, A., Horvath, L. 2013, 313).

Because the organic matter play an important role in the formation of humus and moisture retention into soils (Mahmood, R., Legates, D., Meo, M. 2004, 140), which has a favorable effect on other properties of the soil, it is also important to protect the soils by adding mulches.

This would on the one hand return to soils organic matter, and therefore, increased value to self-retaining ability. Everywhere where soils are acidic and with low base of cations, would also contribute to soil fertility. This shows that already established permacultural approaches with those vertical gardening also spread across Europe and affect the increase of self-sufficiency at the local level. Because the organic matter play an important role in the formation of humus and moisture retention into soils, which has a favorable effect on other properties of the soil, it is also important to protect the soils by adding mulches. By doing so on the one hand returned to soils organic matter, and on the other hand, increases their ability to self-retaining ability.

By adding mulches we increased share through organic (humus), and by doing so we reduced evaporation from the soil surface and protect the plants against external influences (heavy rain, wind). Loss of soil organic matter reduces the ability of soils for water infiltration, resulting in larger run-off and drought. Therefore, permaculture is important not only for food, but also broader. Or, as wrote the Hemenway "Permaculture goes a step further as it seeks also to political strategy, global environment healthy and over time restore in a friendly way" (Hemenway, T. 2009, 15).

8.Conclusion

Improvement of the physical properties of the soil after two years of use permacultural approach shows the benefits brought by this kind of care for the soil. The great importance of organic matter in the soil, it is also important that permacultural approaches adapt to climate change. Mulch significantly affects primarily to keep humidity in the upper horizons.

Pseudogleys due to a higher proportion of clay at a depth retain moisture in humid periods for droughts, whereas these options do not exists, so the soil type pseudogley needs organic matter to be added (this can be seen on the case of arable land, which is not articulated into organic matter, as it was regulated only 2 years ago, and on the case of perches, which has the added organic material into depth).

Therefore, permaculture systems for soil treatment significantly affect the retention of moisture into soils especially under extreme climate conditions. Because of the need for sustainability (Csete, M., Horvath, L. 2012, 190), it is important at all levels from local, regional and national to take care for the responsible use of natural resources, which also includes the pseudogley soils.

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