G.R.E.E.N.: Generare Risorse Ed Economie Nuove
(Generating New Resources and Economies)

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Abstract: The project aims to realize interventions for phytodepuration and to evaluate the remediation capacity of the best Hemp variety (s) as a hyperaccumulator of heavy metals. Hemp (*Cannabis sativa*) can be used to reclaim the soils using an innovative, eco-friendly and low-cost technique called phytoremediation. Hemp is suitable to be used to recover soils, as it is easy to grow under different pedo-climatic conditions, is can be re-introduced in current cropping systems and produces high exploitable biomass for the Non-Food sector. The project aims to explore the potential uses of hemp and its contribution in promoting sustainable development (products) and investigate the potential carbon sequestration potential in the soil and evaluate different agricultural management practices, evaluating CO_2, N_2O and CH_4 emissions related to certain climatic conditions (*those provided by the IPCC - Intergovernmental Panel on Climate Change*).

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1 INTRODUCTION

Phytotechnologies (phytodepuration) are environmental restoration tools that use herbaceous plants or trees for the treatment of contaminants such as heavy metals, radioactive elements and organic compounds in the soil, groundwater, surface waters and discharges of agricultural origin, civil or industrial (Baker et al., 1991; Raskin et al., 1997; Wenzel et al., 1999). These technologies have become interesting alternatives to conventional purification and remediation systems, thanks to the relatively low costs and aesthetic characteristics of the treated sites. At the base there is the set of biological, chemical and physical processes that allow the absorption, seizure, biodegradation and metabolization of contaminants.

Hemp has been successfully used in the treatment of water and soils contaminated by heavy metals, radionuclides and aromatic compounds (hydrocarbons and PCBs) (Citterio et al., 2003; Linger et al., 2002; Vandenhove et al., 2005 ; Kos et al., 2003, patent WO/2008/029423). The high production of biomass, the great plasticity, which allows the cultivation of hemp in a wide variety of agro-ecological conditions and the possibility of using its biomass in non-food industries, make this species attractive for phytoremediation (Linger et al., 2002; Citterio et al., 2003; Arru et al., 2004). Reduction of erosion and dispersion of polluting substances, improving water quality (Haynes and Swift, 1990; Six et al., 2002); retention control and water infiltration (controls flooding by redistributing the load of precipitation) (Sparkling et al., 2006, Reed, 2007); improves soil biodiversity thanks to the radical increase that allows the sequestration of more carbon; increases soil fertility and productivity (Reed, 2007, Rice et al., 2007). Soil remediation: reduce the pollutant load and allow agricultural activity in contaminated sites (Colao et al., 2015).The G.R.E.E.N. project connects directly to the issues of environmental sustainability, global pollution and the common interest.

1.1 Motivations

Hemp is an annual plant that takes a year to complete its life cycle. The peculiarity of annual plants is to ensure the propagation of the species through the production of seeds during the final stage of their cycles. Furthermore, *Cannabis sativa* is a dioecious plant, however the monoecious cultivars are highly

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appreciated in agronomy. Hemp presents a rich root system made of aboundant secondary roots and a taproot, which allow the plant to have more autonomy in terms of water supply, and an erect stem. The leaves are palmately compound or digitate, with serrate leaflets and are mostly opposite, with 3-9 lanceolate, sharp, serrated and pubescent segments. (Colao et al., 2015)

1.1.1 Phytoremediation

Phytoremediation is the ecological science that uses cropping systems (annual species or trees) to remove heavy metals and other toxins from contaminated soil. Using specific plants and trees (called hyper-accumulators) in polluted areas, contaminants can be considerably reduced. Why hemp is superior to other phytoremediators? Hemp grows rapidly producing consistent amounts of above-ground biomass, reaching full crop development in just 180 days and produces roots extending deep into the soil up to 2.5 meters. At that level, the toxins can be extracted without removing the contaminated soil of the top layer, thus avoiding the expense of transportation to off-site disposal plants. (Colao et al., 2015). Moreover, hemp is the best of "remediators" because:

- its ability to grow not affected by toxins collected in the plant;
- its fast absorption rate and its ability to bind air and soil contaminants compounds;
- Hemp actually removes CO_2 from the air as well as removes heavy metals and other pollutants from the soil.

1.1.2 Direct and Indirect Environmental Benefits

- Hemp cultivation requires low amounts of chemical treatments such as pesticides or herbicides;
- Within the sustainable cropping systems, hemp plays a positive role because it regenerates the soil making it more fertile thanks to its properties (reduction of weeds) and thanks to its root system, which works the soil in depth (up to 2 meters), leaving it in excellent condition for the following crop;
- It grows fast (up to 10 cm/day) preventing weeds from developing, and as a consequence use of herbicides decreases. Moreover, thanks to the allelopathic substances contained in the leaves, reduces the growth of weed species;
- It helps to mitigate climate change. The result of a study conducted at the University of Edinburgh, highlights the ability of hemp to sequester atmospheric CO_2 into the soil.

1.1.3 Design Criteria

- Use of plants and environmental control as a method of environmental remediation;
- Inclusion of hemp cultivation in the cultivation systems in the intervention area
- In-depth study of cultivation techniques: irrigation, fertilization, mycorrhization, variety comparison and physiological parameters such as the development and growth of the species, both productive and qualitative parameters, in order to identify the most suitable agronomic management strategies to guarantee environmental sustainability. of production processes
- Effect on the soil-plant-atmosphere system
- Simplicity as a synonym of design effectiveness;
- Planning of targeted social interventions for the dissemination of environmental awareness;
- Creation of a new land use system thus demonstrating that it has the potential not only to clean the environment, in its broadest sense, but also to create jobs and sustainable resources for the community, according to the principles of the green economy, circular economy and bioeconomy.

1.2 Objectives

The goal of the project is the remediation of the polluted areas subject to intervention.
Furthermore:

- Acquiring experimental elements for the design of better performing phytodepuration plants;
- Measuring experimentally and statistically the effectiveness and efficiency of the abatements;
- Measuring the effectiveness and efficiency of the various technical solutions in the realization of natural plants;
- model calibration;
- experimentally verify the effectiveness of phytodepuration to break down heavy metals, organic and inorganic micropollutants;
- measuring the effectiveness of pro solutions;
- financial and economic value;
- contribution to biodiversity;
- increase in green building techniques.

In summary, the operational objective is the research aimed at validating a good practice that includes the cultivation of hemp as an integral part of

strategies promoting the mitigation of climate change and sustainable development.

2 METHODOLOGICAL APPROACH TO RESEARCH

The phytodepuration system will be characterized by a multidisciplinary approach (agronomic, chemical and biological). The need, expressed in the planning step, to implement a transformation of the "environmentally sustainable" territory, highlighted the theme of providing a particularly attentive design approach not only to the problems related to remediation, but more generally to the "sustainable management of the whole supply chain".

2.1 Methods

- Cost-effectiveness analysis;
- Floristic, vegetational and ecostational dynamics analysis;
- Statistical analysis;
- Systematic statistical comparisons and and multi-scale culling for all variable combinations;
- Technical-economic comparisons of the plant.

2.2 Procedural Steps

1. Data collection;
2. Sampling and certified analysis of soil;
3. Soil preparation;
4. Sowing varieties of Hemp (EU CERTIFIED SEEDS): FUTURA, JUBILEU, FIBROR, FELINA, USO 31, SANTICHA, and others available at the time of sowing;
5. Sampling, certified analysis of soil and plants in an accredited laboratory and evaluation of the results;
6. Primary transformation of the harvested plants;
7. Final use in green building;
8. Repeating the cycle.

3 LOCATION

The intervention area is located in the Lama Balice Regional Natural Park, near the Bari International Airport, in particular in the quarry in the area, which has been abandoned for some time. The area was granted on loan for use and it is approximately 1 hectare.

Figure 1: Preparation of the soil.

4 EXPECTED RESULTS

The actions described below will support the achievement of the following results:

- Collection of data (agronomic, hydromorphological, chemical-physical and biological) to estimate variability in the project area;
- Demonstration of the advantages deriving from the use of a phyto-purification system, including the low environmental impact, the low need for management and a near zero energy consumption;
- Validity of the construction of a phytodepuration system for the remediation of polluted soils, which represents not only a valid alternative to traditional remediation techniques, but above all a solution which, fully respecting the environment, is close to the needs of the sector operators;
- Assessment of the ability of different hemp varieties to sequester CO_2 in the soil;
- Dissemination of the process in order to make it a "good practice of new industrial culture and circular economy" in Europe;
- Attraction of new private investments in the Puglia Region;
- Increase in added value in the local agro-industrial sector;
- Ideation/certification of new product patents in the future;
- Evaluation of the effective phytoremediation capacity of the different varieties of hemp (as a hyperaccumulator of heavy metals);
- Organization of workshops to disseminate the results achieved;

- Dissemination of results through websites, deliverables, scientific and technical reports and organization of a final conference;
- Validate that growing hemp is a "*win-win strategy*".

5 GREEN BUILDING

With the alarming global increase in carbon emissions and its implications, the need for carbon neutral or carbon negative technologies is of utmost importance and urgency. Cellulose aggregate concrete (CAC) or bio-aggregate concrete has not only the multi-benefits of low density, better thermal insulation and low embodied energy, it can also make use of industrial wastes such as fly ash, slag, etc. One such CAC is called hemp concrete, which is a composite made of hemp hurds and lime based binder. Hemp is one of the world's earliest cultivated crops and has a variety of applications including construction.

The bio-composite (hemp-lime) can find the following building applications:

- Screeds and substrates;
- Masonry cast on site with wooden frame reinforcement;
- Masonry composed of prefabricated blocks;
- Insulation of cavities;
- Internal and external insulation;
- Roof insulation;
- Insulation of attics.

Bio-composite is a natural material that becomes an anti-seismic construction technique and that represents a huge opportunity for the local economy. Thus hemp can help change the future with a view to environmental sustainability, prevention and circular economy. Furthermore, an un-rendered 30 cm thick hemp concrete wall enables a storage of 36.08 kg of CO_2 per m^2.

Figure 2: Hemp building material.

One of the project partners has always adopted new construction techniques, environmentally sustainable and perfectly integrated with the environment.

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