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Solar Energy for Soil Conditioning

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Abstract—

Constant increase of energy consumption by growing population and shortening of natural resources will impose greater limitations of electric energy consumption by various treatment technologies. Shifting from large-scale treatment facilities powered from conventional sources to autonomic, small, and medium size installations supplied from renewables is one of the possible solutions. Results of ozone soil treatment are presented. PV panels supplied, on-site installation for soil treatment is proposed.

Keywords: soil conditioning, solar energy, ozone

I. INTRODUCTION

Shortening of natural resources and increasing of fuel price will impose greater limitations of electric energy consumption in various fields including treatment technologies. Moreover, with increasing of environmental awareness in the society there comes the need of shifting industry and farmers towards clean and eco-friendly techniques, which allow to avoid formation of secondary pollutants during the treatment process. Small ozonation installations supplied with electric energy from renewable energy sources are perfect example of zero-emission technology achieved with reasonable cost.

Anti-microbial properties of plasmas in the case of decontamination of water, ambient air and surfaces were previously widely proven [1-8]. To protect crops and food from the bactericidal, fungal and viral infections usage of ozone was investigated by many research groups. Pollutants might be distributed in soil in several ways: in soil matrix, vapor phase, non-aqueous phase, or groundwater [9]. Ozone based techniques are good alternative to the traditional techniques like heating, flushing with chemical additives, landfilling, incineration, etc. Benefits of ozone applications in agriculture might be summarized as follows:

-use of ozone in soil treatment will not result in the build-up of any environmentally persistent or toxic compounds but ozone itself and O_3 is immediately consumed in the soil treatment process.

-ozone is manufactured on site so it cannot be stored and its sudden release to the atmosphere is not possible like it could occur with compressed methyl bromide or other persistent toxic gases or chemicals used for soil sterilization.

-minimum human toxicity.

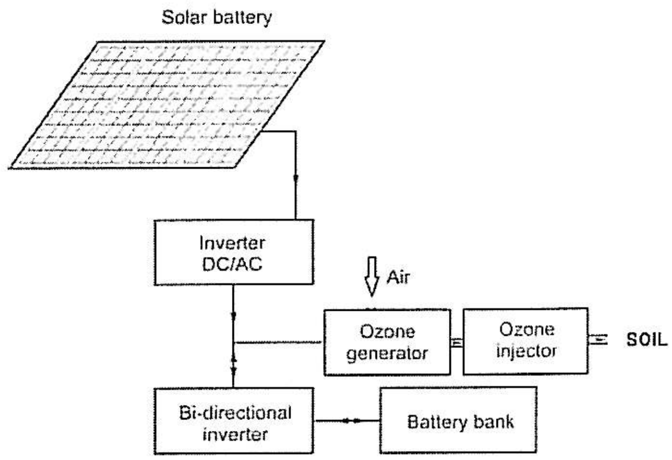

Fig. 1. Soil ozonation system

Fig 1 depicts a small, pilot-scale soil ozonation installation. Presented device is totally autonomous, designed for a constant work in difficult climatic conditions. The system is made of three basic sub-systems: electric energy power system, ozone production system and soil treatment system. The devised technological solution is excellent to be utilized on remote terrains, which are distant from electroenergetic network or in the places where the electroenergetic main is unstable and fallible.

II. Insolation of Polish Territory

The amount of solar energy, which reaches a particular point on Earth depends on latitude and weather factors.

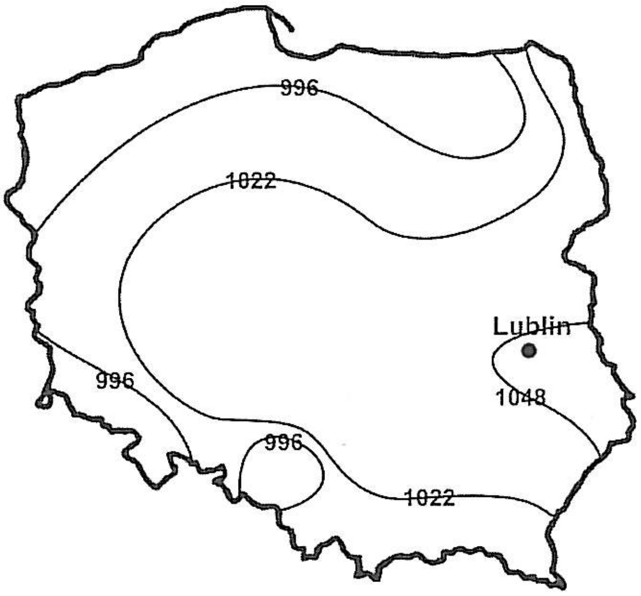

Fig. 2. Total radiation (KWh/m^2).

The average annual insolation on Poland's territory amounts to about 1100 kWh/m^2 (3500MJ/m^2) per year on a horizontal area, which corresponds to the calorific value of 120 kG of theoretical standard fuel (29300 kJ/kg of hard coal, 41860 kJ/kg of petroleum). Fig. 2 depicts insolation map of Polish territory. The insolation of this area is characterized by a big annual diversification. For example, the annual amount for the City of Lublin is about 1107 kWh, and while over 15% of (year) annual energy reaches Lublin in August, in December it is only 1,6% of annual amount.

Currently, the total cost of generating electrical energy from solar batteries is one order of magnitude higher than in case of nuclear energy. However, the application of solar batteries becomes profitable, as far as the demand for electrical energy is small. The correctly selected system should cover about 95÷100% of electrical energy demand during summer. Table 1 correlates photovoltaic cell parameters, used to supply small ozonation system with electrical energy.

III. Experimental Set-up

In proposed solar power energy supply sub-system, the main element of circuits is bi-directional inverter. It administers loads, the flow of energy and the work of accumulators. It constitutes a comfortable link of AC and DC units into one energy system. Inverter creates 24 V grid of DC voltage and a typical grid of AC voltage 110 V 60 Hz or 230 V 50 Hz.

Tab. 1. Photovoltaic cell parameters

Maximum Power	Maximum System Voltage	Maximum Power Voltage	Maximum Power Current	Open Circuit Voltage	Short Circuit Current
210 W	600 V	26.6 V	7.9 A	33.2 V	8.58 A

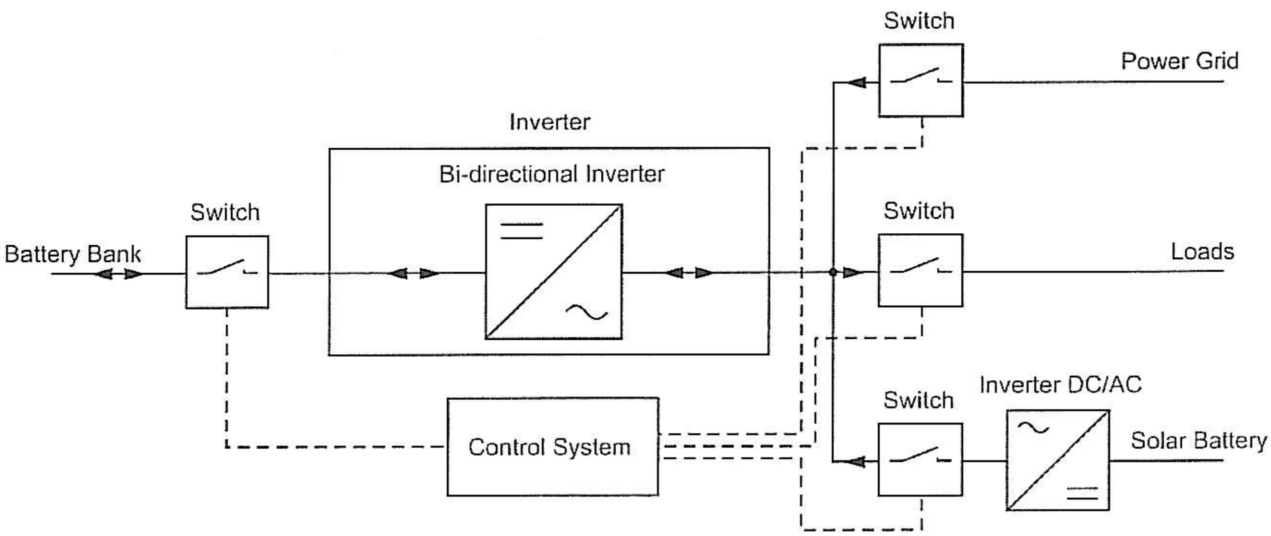

Fig. 3. Grid supplying water ozonation system with electric energy.

Within these grids all pieces of equipment are integrated ranging from electric generators to energy receivers. Photovoltaic systems, air turbine, generators with diesel motors, water-power plants are connected together with load on the side of alternating voltage. The batteries of accumulators, fuel cells and DC receivers, however, are integrated on the side of DC voltage.

Fig. 3 depicts a flow chart of electric grid, which cooperates with soil ozonation system.

The soil sterilization system was using high concentration of ozone generated in TiO_2 based surface discharge commercial OP-20W Iwasaki ozonizer. Ozone generator is presented in Fig. 4.

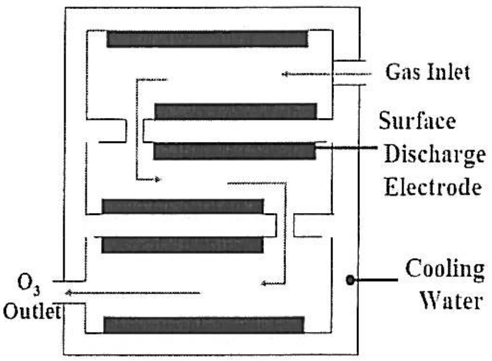

Fig.4. Ozone generator used in the soil sterilization system.

Gaseous ozone injection field-scale system is shown in Fig. 5. It consisted of 10 electrodes and the treatment container, which was developed for sterilizing and monitoring of agricultural soil in large volume. The pH value, electrical conductivity and temperature of the soil were observed to investigate the effect of ozone treatment on soil properties.

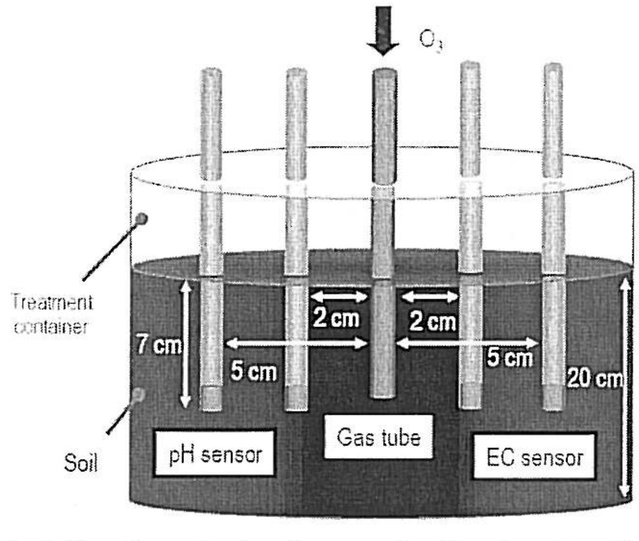

Fig.5. Experimental set-up for general soil treatment: multi-electrode injection system

Fusarium fungal species are widely distributed in soils and organic substrates. Deep sowing makes germinating seeds prone to fungal infections, in particular, at the earliest stages of seed germination, when intensive structural and metabolic changes are involved in embryo activation [10, 11].

Fusarium oxysporum colonizes plants through the roots causing vascular wilt, leaf spots, pre-emergent sprout root rot and post-emergent seedling rot in more than 100 species of plants like tomatoes, bananas, melons, asparagus, basil, etc. [12, 13] affecting them worldwide, especially in elevated temperature zones [14]. The fungus can attack both: plants' seedlings in the transplant house and mature plants in the field. Of the soil-borne diseases Fusarium wilt is the most serious in hydroponic cultivation systems.

Fusarium species produce secondary metabolites caused mycotoxins. They cause a toxic response termed a mycotoxicosis, when ingested by higher vertebrates and other animals. It can lead to the deterioration of liver or kidney function [15]. There are several traditional methods used in prevention of Fusarium-caused infections:

-chemical fumigation (one of the basic fumigants: methyl bromide has been banned worldwide since 2005 due to its environmental risk) [16-18],

-biological suppression (screening and planting resistant cultivars, grafting, intercropping, using antagonists, compost amendment) [19, 20],

- physico-chemical methods: ozone, H2O2, UV treatment, soil heating, solarization [21-24].

IV. Ozone Sterilization

Experiment with ozone penetration depth, which based on discoloring of indigo with ozone to colorless isatin was performed [25]. It was proven that ozone can spread out to a diameter of 8 cm during 60 min of treatment at 1 l/min of gas flow and ozone concentration of 1 g/m3. Ozone sterilization effect on Fusarium oxysporum is summarized in Tab.2.

Tab. 2.Ozone sterilization effect.

Ozone concentration (g/m^3)	Flow rate (lit/min)	Treatment time (min)	Dosage (g)	Sterilization rate (%)
0	3	10	0	22.80
10		10	0.3	97.54
20		10	0.6	99.91
40		10	1.2	100.0
38		60	6.84	100.0
38.5		60	6.93	100.0

Conventional biological method of the CFU (colony forming unit) counting showed that bacteria and Fusarium oxysporum in the soil were almost eliminated by ozone treatment with the concentration over 20 gO3/m3, achieving sterilization rate up to 99.9%. Sterilization requires ozone dosage over 0.6 g for the 50g soil.

V. Conclusions

The presented soil ozonation system is currently being prepared for implementation procedures. Since it is a fully autonomic system of modular construction, it can be easily adjusted to individual needs.

It was possible to achieve 99.9% sterilization efficiency in the case of Fusarium oxysporum at the ozone dosage over 20 gO3/m3.

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