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A Review on the Agri-voltaic and Fence PV System

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ABSTRACT: Solar energy is rapidly being utilized to generate power in Europe and other countries, but the environmental effect of building and operating solar farms is not fully understood. The building of a solar park demands the removal of certain vegetation and the leveling of the land. Solar energy infrastructure may involve considerable landscape change, altering soil biological processes and influencing hydrologic, carbon and vegetative dynamics. To rebuild the solar PV facilities soils, inherent plant fields might require to be re-established. Within the scope of this research, we presented an analysis of the effects that were caused by the solar farm.

Key words: Fence PV, Agri-voltaic, Bifacial, Solar farms, Soil analysis

Nomenclature

PV : Photovoltaics
AV : Agri-voltaic
GISQ : Generic indicator of soil quality

Subscript

cSQ : chemical soil quality
pSQ : physical soil quality
mSQ : microbiological soil quality

1. Introduction

Due to technological developments and helpful government regulations, solar photovoltaics (PV) have recently ranked among the energy technologies with the quickest growth rates[1-2)]. Additionally, it prevents the greenhouse gas effects, air quality issues, and other forms of pollution caused by the usage of fossil fuels[3-5)]. Different methods of deploying PV technology exist. Installing solar panels on the rooftops of homes or businesses is a common strategy. These panels are impermeable panels with PV cells. Ground-mounted solar panel arrays are another method of capturing solar energy, notably on a bigger scale than residential rooftop solar. Solar farms are the popular choice for utility-scale, ground-based solar panel, arrays used to generate energy with a capacity of at least 1 MW[6)]. When constructing a solar farm, the soil surface must be cleared and graded, electrical lines must be buried, vegetation must be removed, and soil compaction increases runoff and erosion. The physico-chemical characteristics of soils were altered by grading, compaction, and erosion thus lowering the quality of the soil[4)]. In a variety of climatic and geographical circumstances, there is a limited but increasing number of scientific studies attempting to comprehend the effects of solar farms, particularly on landscape ecohydrology. We examine the most recent research on how solar farms affect the hydrology of the landscape and associated soil and plant characteristics.

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2. Review of the impacts of solar farms

A solar farm in Colorado, USA, was studied and found to have a large amount of soil coarse particle percentage than a neighboring native grassland reference. The variation in soil particle size is probably caused by erosion of the fine particles due to soil disturbance and plant elimination during the solar farm's development phase[7)]. Using an adjusted generic indicator of soil quality (GISQ), comparison research on four different land use types[8)] revealed that the quality of anthropogenic soils was 1.5 times worse than that of naturally available soils in the field. Joimel et al[9)]. discovered a reduction in physico-chemical quality of soil with an enthronization variation to urban soils from forest, although Joimel et al.[10] found no variations in soil's biological quality. Solar farm installation might degrade soil quality and have an impact on ecosystem processes such water penetration and storage, plant regrowth, nutrient cycling and organic matter. Such land use categories include forest, shrubland, and abandoned vineyards[11-15].

The considerably lower amount of nitrogen and carbon contents in PV soil compared to reference soil were most possibly caused by topsoil exclusion during array installation. With the consistent in addition to other research, which showed decreased into soil organic matter in plant yield output by testing with intentionally removed topsoil to simulate erosion[16, 17]. Considerably low nitrogen (50%) and carbon (38%) were present in the soil at solar PV location than the reference soil as shown in Figure 1.

Modeling runoff and keeping track of the effects on micro-climate have been the main areas of attention in earlier analyses to check the effects of solar infrastructure on the environment[18, 19].

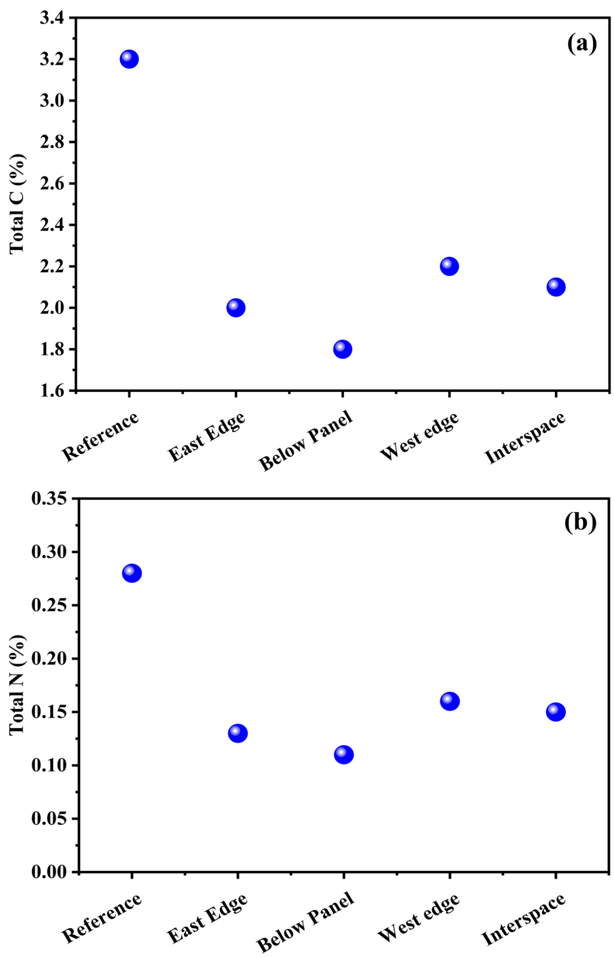

Fig. 1. (a) the percentage of carbon and (b) the percentage of nitrogen in the soil that serves as a reference and is located underneath solar modules[7].

For example, according to an assessment, preparation of the location for PV arrays often involves removing plants that deteriorating the soil, which significantly raises onsite runoff and soil erosion[20]. Furthermore, variations in the topography, vegetation, and albedo might result in higher air temperatures above PV arrays than in nearby natural regions[19]. The chemical, physical, microbiological sub-indicators of soil quality are denoted as cSQ (chemical characteristics that impact fertility and plant regrowth in solar farms), pSQ (physical characteristics that affect water infiltration and storage) and mSQ (micro-biological characteristics that cause decomposition of soil organic matter and nutrient cycling), while general soil quality index is represented as SGQI. In comparison to semi-natural and abandoned vineyards, the pSQ in solar farm was two and four times lower, respectively as shown in Figure 2. The solar farm and abandoned vineyards has a cSQ of 0.18, which was four times lower than the shrubland and pinewood. Figure 2 illustrates that the mSQ did not significantly vary amongst the various land cover categories.

3. Fence type bifacial photovoltaic farms

One of the issues with adopting a normal solar array having fixed tilt construction that oriented towards North/South (N/S) for agri-voltaic (AV) farming is geographical diverse in daily sunshine supply for crops and soil water levels, that can impact plant output yield altogether. The research of inclined vertically bifacial AV farms may be appealing in areas with significant PV losses owing to dust. Several research have recently investigated the possibilities of vertical East/West (E/W) faced bifacial PV

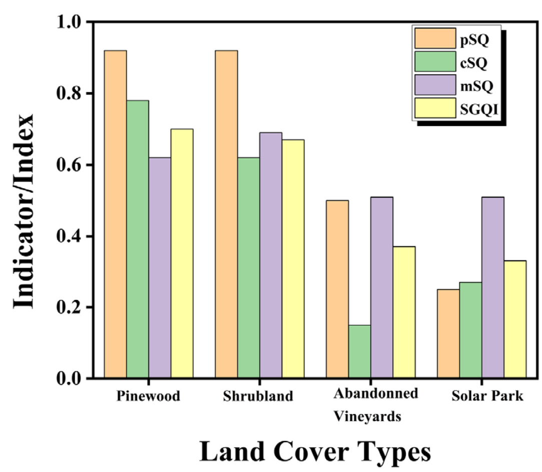

Fig. 2. Chemical, physical, microbiological and considering various forms of land cover, a general indication of soil quality[4])

Fig. 3. Application of Fence type bifacial PV system installed at Kyungpook National University's agricultural field in Korea

farms for AV systems. Investigation the possibilities of AV systems using vertical E/W facing bifacial PV farms has been done by Riaz et al.[21, 22]. In terms of PV energy production and photosynthetically active radiation (PAR), the findings demonstrated that standard N/S facing tilted farms and vertical bifacial farms both performed equally well at half PV array density. An example of on-farm Fence type bifacial PV system is shown in Figure 3. It was discovered that E/W vertical PV farms demonstrated geographical uniformity for crop light among AV farms, but N/S facing PV farms showed longitudinal diversification[23]. Given that, dust has a low potential to build on vertical surfaces and the vertical tilt is especially well suited for environments with significant dust components[24]. As the tilt of the PV panel changes from horizontal to vertical, PV soiling (dust formation) losses are known to be significantly reduced[25]. The area near the structure for mounting that unable be utilized for agriculture around 10% for mounted vertically AV arrangements can be employed as pollinator environment and to improve with agrobiodiversity, which is favorable and benefits for plants output yield[26-28] gave a good results thorough examination and issues related to the ideas of the economy, green economy, and bio economy. A realistic nexus model of water-food-energy was built for the modeling and optimization of perpendicularly installed AV systems[29].

4. Future works

Due to the destruction of vegetation and changes to the soil caused by solar park development, a thorough examination of the environmental effect of solar farms is required[30, 31].

5. Conclusions

The construction of a solar farm requires the removal of the plants as well as the leveling of the soil field. Solar energy infrastructure may significantly modify the landscape, affecting the hydrologic, carbon, and vegetative dynamics as well as the biological activities that take place in the soil. The particle size variation is most likely caused by erosion of fine particles produced by soil disturbance and plant eradication during the solar farm construction period. The significantly reduced nitrogen and carbon percentage concentrations in PV soil as compared to reference soil were most likely caused by topsoil removal during array installation. The cSQ in the solar farm and abandoned vineyards was 0.18, which was four times lower than the shrubland and pinewood. The mSQ did not considerably differ amongst the various types of land cover. In regions with considerable losses of PV output because of contaminated soil particles on PV surfaces, the study of vertical inclined bifacial AV farms may be interesting. PV soiling (dust generation) losses are known to be greatly decreased as the tilt of the panel changes from horizontal to vertical.

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