

The Photovoltaic Panel at End of Life: Experimental Study of Metals Release

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Abstract : The solar photovoltaic (PV) modules are considered to have a negligible environmental impact compared to the fossil energy. Therefore also the waste management and the corresponding potential environmental hazard needs to be considered. The case of the photovoltaic panel is unique because the time lag from the manufacturing to the decommissioning as waste usually takes 25-30 years. Then the environmental hazard associated with end life of PV panels has been largely related to their metal contents. The principal concern regards the presence of heavy metals as Cd in thin film (TF) modules or Pb and Cr in crystalline silicon (c-Si) panels. At the end of life of PV panels, these dangerous substances could be released in the environment, if special requirements for their disposal are not adopted. Nevertheless, in literature, only a few experimental study about metal emissions from silicon crystalline/thin film panels and the corresponding environmental effect are present. As part of a study funded by the Italian national consortium for the waste collection and recycling (COBAT), the present work was aimed to analyze experimentally the potential release into the environment of hazardous elements, particularly metals, from PV waste. In this paper, for the first time, eighteen releasable metals a large number of photovoltaic panels, by c-Si and TF, manufactured in the last 30 years, together with the environmental effects by a battery of ecotoxicological tests, were investigated. Leaching tests are conducted on the crushed samples of PV module. The test is conducted according to Italian and European Standard procedure for hazard assessment of the granular waste and of the sludge. The sample material is shaken for 24 hours in HDPE bottles with an overhead mixer Rotax 6.8 VELP at indoor temperature and using pure water (18 M Ω resistivity) as leaching solution. The liquid-to-solid ratio was 10 (L/S=10, i.e. 10 liters of water per kg of solid). The ecotoxicological tests were performed in the subsequent 24 hours. A battery of toxicity test with bacteria (*Vibrio fisheri*), algae (*Pseudochirneriella subcapitata*) and crustacea (*Daphnia magna*) was carried out on PV panel leachates obtained as previously described and immediately stored in dark and at 4°C until testing (in the next 24 hours). For understand the actual pollution load, a comparison with the current European and Italian benchmark limits was performed. The trend of leachable metal amount from panels in relation to manufacturing years was then highlighted in order to assess the environmental sustainability of PV technology over time. The experimental results were very heterogeneous and show that the photovoltaic panels could represent an environmental hazard. The experimental results showed that the amounts of some hazardous metals (Pb, Cr, Cd, Ni), for c-Si and TF, exceed the law limits and they are a clear indication of the potential environmental risk of photovoltaic panels "as a waste" without a proper management.

Keywords : photovoltaic panel, environment, ecotoxicity, metals emission

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