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Solar photovoltaic panels as next generation waste: a review

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ABSTRACT

Photovoltaic energy manufacturing has developed at an extraordinary rate since the last decade which globally has reached 225 giga watts by 2018 and is anticipated to augment to 920 giga watts by 2022 and 5000 giga watts by 2050. Still now the abundant quantity of produced solid waste which comes from the end of life panels are not calculated yet but in future it can be a challenging aspect in terms of photovoltaic energy. Harmful waste from end of life solar panels poses a global ecological menace and is capable of creating 300 times more toxic waste than nuclear plants. This review represents an overview of global scenario on different types of solar panels production with their composition, applications, solid waste generation, loss of precious metals (rare earth metals, metals), utilization of metals in different industries and different toxicological effects on the environment and the requirement of recycling of used solar panels. The recycling of these solar panels after life can be an economic alternative source of natural resources.

Keywords: *Solar Cells; Solid waste; Toxicological effect; Precious metals; Recycling.*

1. INTRODUCTION

Solar energy is one of the readily available renewable energy sources used in existing knowledge development in every region. In between 2010 to 2040, energy use is predicted to mount by 57% from 520-810 quadrillion British thermal units (Btu) [31]. Even though varied substitute energy resources are present including wind energy, geothermal energy, biomass and many more, the potentiality of solar energy is highest in nature [21]. In the year 2017 the usage of solar energy is 0.008TW which almost 0.5% of total potential energy [1].The steady declination of conventional energy and their unsafe effect on nature redirects mankind for a renewable source of energy like solar, geothermal, wind and biomass etc. A Schematic diagram representing the most appropriate source between fossil or green energy is provided in Figure 1.

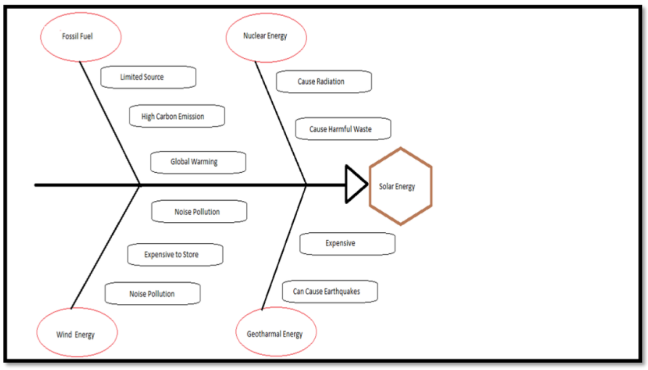

Figure 1. Fishbone diagram for different energy sources and their effects on environment.

Renewable energy contributors have their own potentiality but unluckily till date10-15% of the resources have been employed. A list of non-conventional energy sources and their quantity of usages till 2017 is provided in Table 1. Each year about 5.4 million EJ of solar radiation reaches on earth surface Figure 2[38]. According to International Energy Agency report, 2017 solar energy becomes world's fastest rising energy source rather than all other renewable fuels [31]. Regarding the most uses of solar energy, China is in the top position. According to the IEA data China previously surpassed its 2020 solar PV objective and contribute half of the global solar energy claim[40].United States occupies the second largest growth market for solar energy with their multi-year federal tax incentives which are shared with the renewable portfolio standards for distributed solar PV. In the solar energy sector for the first time the growth forecast is superior as compared to the European Union [31]. In association with the International Solar Alliance, India promotes some most important projects on solar energy like off-grid power supply hubs, street lights, irrigation, green buildings and generate a respectable position among the other developed countries. An original graphical analysis of country wise production and utilization of solar cell is represented in Figure 3.Thisscenario shows that the current worldwide consumption of photovoltaic panels and till 2017 it is estimated that 870 tons of waste solar panels are accumulated as solid waste in nature. In the present rate it is expected that by the year 2038at near about 1957099 tons of waste panels will be dumped all over the world[23]. Regular life of a solar panel is 25 years and the total amount of solar panel is increasing gradually in global market. The residue or the chemicals produced from the waste can literally effect the flora and fauna of the earth[10-11] , which causes many diseases like lung fibrosis, fast aging etc [18]. The secondary components like ammonia, arsenic during the production are also hazardous for nature [8], [18-19]. These ends of life (EOL) panels should be recycled properly or it will create a massive amount of solid waste generation which can be the genesis of many environmental effects. The main objective of this review is to analyze those harmful effects and try to minimize it from now on or in future solar cells will be a major problem for global extinction like the fossil fuel in present days.

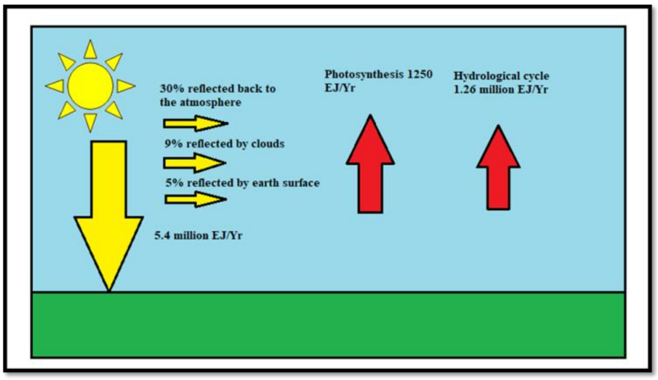

Figure 2. Solar radiation throughout a year over earth.

Figure 3. Original schematic diagram of global Production and Utilization of Solar cell.

Table 1. Different types of renewable energy source.

Sl. No.	Source	Estimated Potential	Present Installed	Reference
01.	Solar Energy	6500 TW	0.008 TW	[1]
02.	Wind Energy	0.045 TW	0.003595 TW	[2]
03.	Geothermal Energy	1.2 TW	0.0132 TW	[6]
04.	Biomass Energy	0.016 TW	0.00030 TW	[2]

2. SOLAR PANEL: TYPES AND COMPONENTS

Multiple solar cells are interlinked together to form solar panel which is further linked together to form solar array. Photovoltaic solar cells are basically semiconductor element which can differ on the basis of manufacturing, band gap and crystallinity. Some solar panels are single junctions and some are multiple junctions on the basis of their various applications. There are different types of cells are present on basis of utilization like some solar cells are planned and constructed to optimize sunlight on earth's surface and some are used at space, but there are basically three phases of solar cells still now, they are Crystalline silicon(First generation): use wafer based cells which are made of poly-silicone and mono-crystalline silicon, Polycrystalline silicon(Second generation): which are CdTe and CIGS cells and amorphous silicon, use in small scale photovoltaic power station and Thin film(Third generation): Made by thin layers of semiconductors, zinc or tin oxide, glass which made this more efficient and more cheaper[1], so this is the most upcoming and upgraded technology, which are still in a R and D phase [38]. Photovoltaic cells are the medium through which solar energy is converted into electricity and these cells are composed with layers of silicon crystals which act as a semiconductor. The bottom layers of photovoltaic cells are doped with boron and the top layer with phosphorus to facilitate positive as well as a negative charge. At the p-n junction electron movement towards p to n type layer due to electric field [21]. Due to the heating up with photon particles both layers arecharged up to transfer electrons. There is an external circuit present to transfer electrons from n type top type layer which creates the electricity [28]. From the IEA's electricity forecast shows there is a continuing strong expansion during 2022 and the capability estimate to increase by over 920 GW, an increase of 43%. A Schematic representation of Production and Utilization of Solar cell globally till 2017 is provided in Figure 4.

So in solar panel silicon is basically use as a solar radiation absorber but scientists searching for an alternative absorber. They are trying to reduce the dimension to the 100µm from 180µm. Using the thin film technology new absorbers are going to use like microcrystalline silicon, cadmium telluride, CIGS etc. These absorbers can bring down the cost of cell but consists of a major drawback which is thin film solar cell are less efficient than crystalline silicon solar cell [32].Chromium is also used nowadays as a chromium trioxide, for hole-selective transport material with a greater efficiency [27] but in the other hand again chromium is a carcinogenic compound for the environment t[9]. Chromium which is a strong oxidizing agent can be an immunotoxic, genotoxic and also be mutagenic for living beings in a high amount. The measurement of performance quality of a solar photovoltaic module, there are few output parameters. VOC (V) - solar cells are measured at two voltage level, the first one is VOC or Voltage open circuit. VMP (V) – Voltage maximum power is the second voltage rating point where module has the maximum power. ISC (A) – Now the current passing through the photovoltaic module also measured in two levels, one is Short circuit current. Imp (A) – The second one is the Maximum power point. In this point maximum ampere of power delivered to the module. Pm (W) – here maximum power and maximum power point is equal to amperes time volt. A complete solar energy system is consisting of a solar panel, a solar controller and a group of batteries. There are different medium through which solar energy came to the collector or group of special alignment of mirrors. These collectors are of different types due to their application like for stationary tracking there is compound parabolic collector (CPC), flat plate collector (FPC),evacuated tube collector (ETC) with operating temperatures 60-240,30-80 and 50-200°C.Solar panel manufactured by mixing of different metallic and non-metallic components like aluminum(Frame), glass, EVA(Ethylene/vinyl acetate copolymer) etc. scientists are also trying to put manganese doped and change the band structure to increase in efficiency [13]. There are many rare metals are also present like indium, gallium, germanium etc. which are used in different models on the basis of different needs. Indium is used in amorphous panels and CIGS panels. Gallium is used in CIGS panels to concentrate PV cells so as germanium is used in amorphous silicon panels. In case of crystalline silicon panels there is different rare-earth metals used like tellurium, cadmium etc.

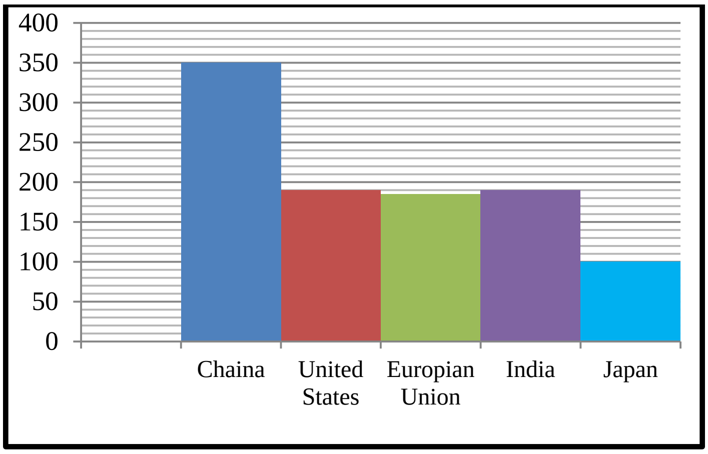

Figure 4. Production and Utilization of Solar cell globally (Till 2017).

Several types of chemicals are also used during the production of solar panels. The quantities of chemicals are depending upon semiconductor materials. In case of crystalline silicon cells chemicals like ammonium fluoride, hydrochloric acid, isopropyl alcohol, nitric acid and sulfuric acid are used during manufacturing. For amorphous silicon cells chemicals like acetone, hydrochloric acid, hydrofluoric acid, Iso-propanol, and silicon tetra fluoride are used. Ammonia, ethyl acetate, hydrogen peroxide, nitric acid, titanium dioxide etc. are used for polycrystalline silicon cells. Acids and other corrosive liquids are also used for removal of dust particles and impurities from raw semiconductor materials. Chemicals like acetone, Iso-propanol are used for different cleaning steps during manufacturing. The number of chemicals are used on different parameters depend upon the product, amount of raw material and for cleaning purposes(California Energy Commission, 2004). The huge demand for solar panel creates different types of PV cells for commercial use which are given below in Table 2.

Table 2. Different types of solar PV cells.

Sl. No	Name	Functions	References
1	Cadmium Telluride Solar Cell(CdTe)	With the help of cadmium telluride high production rate of electricity and low manufacturing cost, used in famous solar industry of USA, Topaz Solar Farm.	
2	Thin Film Solar Cell(TFSC)	Combinations of thin metals, glass or plastic which makes it cheaper but as a disadvantage decrease the rate of electricity.	
3	Poly-crystalline Photovoltaic Cell	Very ordinary type of photovoltaic cell with high filtered silicon particles as raw material.	
4	Mono-crystalline Photovoltaic Cell	Used as a photon particle absorbing material l in photovoltaic cell and also used in our daily basis electronic apparatus.	
5	Dye-Sensitized Solar Cell(DSSC)	It is highly advanced technology creates electricity from any visible light like the photosynthesis process in nature.	[20]
6	Amorphous Silicon Solar Cell(A-Si)	With the help of PVD method at a minimal temperature (75°C) non crystalline silicon generated which is used in small buildings and shops to produce electricity.	
7	Buried Contact Solar cell	High efficiency commercial technology based on metal plated inside a laser-formed groove.	
8	CIGS(Copper Indium Gallium Selenide Solar Cell)	With the help of thin layer of heavy metals like selenide, indium, gallium and copper creates a very good absorbent of solar energy and also low in weight.	
9	Biohybrid Solar Cell	It is an advanced generation of solar cell with the mixture of both inorganic and organic matter, still in a R&D phase.	

3. ENVIRONMENTAL POLLUTION AND TOXICITY FROM SOLAR PANEL

Solar energy is remarked as a green source of energy but it has some environmental issues which are also important factor for mankind because every solar cell has life duration and after its end of life it just acts as a waste. So for the upcoming generation there have some long term problems when a green energy source converted into a lethal poison for the environment. Now a day's every country in the world started mass production of solar panel which can also open a new window for environmental pollution. Researchers continuously work to increase the duration or the efficiency wherein the other hand used or damaged panels create more complex issues gradually. Photovoltaic cells are basically made up of silicon not much harmful for nature but it doped with boron and phosphorus and mixed with different metals like cadmium, selenium, arsenic which are lethal to living cells as well as to the environment. In case of new generation photovoltaic cell CdTe, CIGS issued and during processing ethyl vinyl acetate (EVA) issued to encapsulate the material due to its thermal, mechanical properties and high diffusivity for water [25] and during assembling of the system various metals like copper, aluminum, chromium and tin used [29]. Manganese also made its mark as a soil and aquatic toxicity [15].Those all metals are hazardous for the environment and somehow affect the living beings [30]. The major pollutants including heavy metals, plastics and biomedical wastes are polluting the whole ecosystem starting from soil to aquatic systems [41-43]. Emerging technologies are now being developed for the instant detection of environmental and biological health hazards for human exposures.

Many countries have already applied several policies to recycle the damaged or used cells to decrease the toxicity but still now this technique is not very much efficient. The main reason of this inefficiency is the less quantity of waste cells. It will be effective when there is a large number of solar wastes are present. A statistical data shows that in 2040 Europe, the total amount of wasted solar material will be 33500 tons. Another data shows that all over the world during 2035 the total amount of solar waste will be 3000000 tons among them 45000 tons will CIGS panels [33].

There are two categorical effects on the human for photovoltaic solar cells- Carcinogenic effects and non-carcinogenic effects. Carcinogenic effects can cause tumor formation in humans and animals whereas non-carcinogenic effects can cause damage in nervous system, reproductive system, decrease the immune system and reduce growth. So due to the lack of recycling process these hazardous materials are getting inside our body through oral consumption, air inhalation and skin adsorption. The non-carcinogenic compounds used in solar panels are selenium, zinc phosphide, molybdenum and trichloroethylene have low oral inhalation effects. Carcinogenic compounds are arsenic, cadmium, arsine and dichloromethane which contain not only cancerous effect but also they have other hazardous effects on the environment [17].Starting from the manufacturing to the end of its life a single solar panel came in contact with different compounds or chemicals whether during production or use. Those compounds or chemicals have their own effects on environment, including- Cadmium which is used as cadmium telluride act as a semiconductor is highly toxic. It can cause prostate, lung cancer, diarrhea respiratory issues etc. Lead, which is also a toxic element used in solar cell wires, can cause brain and kidney damage, lower the calcium level in bones etc. Arsenic is used in GaAs solar cells, causes lung cancer, liver damage, throat infection etc. For anti-reflection coatings on the panels ammonia is used which causes lung problems, eye damage etc. Silicon, which is the basic need for manufacturing solar panel causes lungs and skin problems. Iso-propanol is used during the production to clean dust particles from solar chips causes vomiting, depression, and respiratory failure (California Energy Commission,2004). These metals can be released to the environment due to many reasons like dumping, vaporization, fusion, sublimation.

These are the direct effects of solar panels to the environment, but it has some economical effects also which is also an important parameter to judge the efficiency of solar panel as an energy source and availability of recycle(Not so green solar energy; American thinker). Today world’s biggest problem is population. Every country has facing many problems due to their huge population in case of living, water or food. Now for a solar industry, there is a need for a huge land which is very difficult to found due to high population [22]. The land cost will be pretty much expensive which also increase the price rate of solar electricity. Large trees and bushes on that area can create an obstacle and decrease the rate of electricity generation, for that reason large trees and bushes are cut down which can lead towards the global warming. Cut down of trees, results in loss of habitat, food for the animals and birds. Yet due to the different environmental issues many animals and birds species are gradually extinct from the face of earth, solar panels toxicity also take one step towards that path. To decrease the amount of dust from the air some kind of chemicals are spread in the air which can affect the air as well as the soil. Soil will be less fertile for any plants and sometimes those chemicals are absorbed to the underground water and pollute it. Large CSP are installed inside the solar industry which are nothing but a mirror to concentrate or gather the solar rays and reflect on the solar panels. These CSP towers are very high and sometimes those reflected solar beams can cause interference with aircraft [1].

So there are two types of impression are created by a dead solar panel in nature, they are dumping of panels and another one is recycling of solar panel. In this case the amount of first one will be deciding the second one. Reusable of panels of recycle is the best way for each and every criteria of manufacturing like the manufacturing cost will be the one third, dumping problem will be solved and almost 80-90% metals will be recovered and the lifetime of these panels will be almost same as the new one [2]. If this kind of processes takes place then the toxicity level will be decreased and some precious earth metals will be recovered [39]. Currently, there are few recycling techniques are invented to extract the metals from the panel and especially from the semiconductor.

4. EFFECT OF CADMIUM TELLURIDE ON ENVIRONMENT AND HUMAN BODY

The solar industry is one of the upcoming and futuristic industries all over the world due to the low cost of solar cells or components. During 2005 to 2010 there is a 30% increase in solar energy use rather than other energy sources throughout the world. Now due to huge increase of solar cells, those industries are walkthrough several generation phase. These generation phases sometimes increase the efficiency of electricity generation or sometimes lower the manufacturing costs with the help of different components. Cadmium telluride (CdTe), amorphous silicon and CIGS metals like indium, copper, selenide, and gallium are the major components for those fast growing industries to make these generation phases. Among these CdTe provides the most beneficial production with increasing the electricity production rate as well as decrease the cost of production, which is coming under the thin film photovoltaic technology [8]. So CdTe solar panels create an upward effect in the energy market but like both side of a coin, it has some negative impacts on the environment as well as in human life. Different scientists provide the negative effect of dumped CdTe solar panels after their life span. To control these negative impacts many countries took some prevention procedures like a particular place for dumping damaged or used solar panels, extract the toxic particles with help of leaching, analyze the toxicity with the help of mass spectroscopy. Toxicity characteristic leaching procedure test or in short TCLP test shows that in case of CdTe panels cadmium, selenium and leads have much higher concentrations, among which cadmium is present in much higher amount [8]. There are many physical effects of cadmium in human body due to high inhale like hypertension, lung diseases, neural effects and osteoporosis. Now according to ATSDR ranking, cadmium got the seventh rank for toxic heavy metal in human body. After getting the exposure it will absorb by the body and gathered inside for the whole life. Unlike direct exposure, it can also collect inside the body indirectly through the plants in the form of food. A study shows that in Japan and China are the most exposed country rather than any other country in the world in case of cadmium. It is a nonessential heavy metal which creates insufficiency of nutrition and negative enzymatic effect in plant cells [3]. Inside the body at the cellular level, it directly attacks the normal cells, attached with the metallothioneins which are cystein-rich proteins and higher the concentrations. After binds with metallothioneins it creates hepatotoxicity in liver and after that it gathered in the renal tissue creates nephrotoxicity in the kidney. It can attach with different nucleic acid like glutamate, histidine and ligands to cause the insufficiency of iron. According to the International Agency for Research on Cancer, it is grouped as Group 1 carcinogens for living beings. Cadmium emission in nature is due to some natural phenomena like transportation of river, climate change or eruption of volcano which are limited. But the quantity increases due to the man made effect like mining, electronic equipment dumping, smoking or through chemical fertilizers. Inside of a human body high amount of cadmium creates chronic intoxication and it can directly affect the kidney's proximal tubular cells. In case of high amount it can create renal stone and also damaging the bone. If it overcomes the critical level in our body, causes osteoporosis. In terms of oral inhale it directly affects the lung and accumulating in the stomach causes vomiting and diarrhea. In a research it was observed that half of the amount is absorbed by the lung and creates abnormality, pregnancy failure, premature birth etc. Now cadmium telluride is synthesized with the help of filtered cadmium and tellurium in a vacuum vycor tube. It is a black colored insoluble crystalline powder with a melting point of 1092°C. Basically it is used in manufacturing highly efficient solar cells due its band gap(1.44eV). But it also used in different ray detector by creating the alloy formation with mercury which is excellent for detecting X ray and gamma ray. It is doped with chlorine particles to detect alpha and beta particles. Rather than its huge involvement in electronic industry it has some major dreadful effect on the environment. One of them is tellurium is the rare earth metal which has a limited source. Another one is this compound can create toxicity in our body by entering orally or by food. Inside the body cadmium telluride converts into toxic cadmium chloride solution which creates an oxygen deficiency at a cellular level in our body.

So basically cadmium is used in manufacturing solar cells as a compound and after the end of life it releases as a cadmium telluride compound in nature but during causing harmful effect in living beings as well as human body. In brief the hazardous effects of cadmium inside the human body are – Oral effects (Respiration) – Cadmium damages respiratory organs by inhales through air like lung disease and emphysema. It is also a possible element of causing lung cancer. It also increases the tendency of bronchitis, damages the olfactory epithelium. Cardiac effects- It also damages the cardiovascular organs. In case of high absorption in the blood through food, it increases the blood pressure which increases the secretion of aldosterone and lowers the amount of sodium and water in the blood. Due to high exposure in the body sometimes it causes peripheral artery disease. The effect in kidney-Due to the huge consumption of cadmium, it also createsrenal damage in the body which is called renal cortical necrosis. Stone formation inside the kidney is also a reason of cadmium exposure. Sometimes due to high concentration it can also cause hyperphosphaturia, uric aciduria, hypercalciuria. The effect in bones- Accumulation of cadmium inside the body results in lowering the concentration of calcium and directly affects the bone formation. Over the critical level cadmium can decrease minerals quantity in bones which creates bone fracture. Itai-itai–It is a disease came from Japanese women, who were getting exposed to cadmium. This disease causes severe damage in renal system with osteomalacia and osteoporosis in bones. It also lowers blood pressure and causes mild anemia [3].

5. EFFECT OF COPPER INDIUM GALLIUM SELENIDE(CIGS) ON ENVIRONMENT AND HUMAN BODY

The first CIGS solar cell was manufactured on 1976 with the rate of efficiency of 4.2%. After that advancement of technology developed this solar cell and gradually increases its efficiency up to 23% till 2016. In this semiconductor n-type junction made of CdS act as a buffer layer and p-type junction made of $Cu(InGa)Se_2$.The main advantage of this solar cell is its thin layer which is 4.05 µm where others are 160-190 µm. Those metals like copper, gallium, selenium and indium consist of high absorption rate of sunlight and make the panel very thin which is called thin film technology. It makes the panel lightweight and highly flexible which is very useful insolar ray deposition. These are the reasons for the popularity of this type of panel. But like others it also creates toxicity after accumulating as e-waste..Metal which is gathered in nature or as well as in human body more than its required level cause damage. Copper which is one of the base metals of CIGS panel can consumed in human body either liquid form or in solid form through food or water. Due to the huge consumption of copper causes acute hemolysis, cardio toxicity, CNS manifestations, headache, mucosal ulceration and bleeding(National Research Council (US) Committe on Copper in Drinking Water, 2000).

So before coming to the toxicity part, first we have to know the mechanism of copper inside our body. During transportation occurs through gastrointestinal tract where copper absorbed by the small intestine, more specifically in duodenum. After that it carries forward to the liver via the hepatic portal vein. There are two stable copper isotopes are used to measure Copper absorption range which is 0.65 mg/day to 6.5 mg/day. Another parameter to measure the copper absorption range is on basis of age and gender. It has been studied that the consumption of copper is 10% higher in a female body rather than a male body. In a human body liver is the highest to absorb copper which is 76% and remaining bound with the albumin protein [5]. Now come to the toxicity risk of copper due to high consumption it creates different activity in different body organism. Like in the presence of a very mild amount of selenium, copper pro-oxidation causes atherogenesis which weakens our body defense system. In a study show that cardiac arrhythmia can also be caused due to copper consumption. Basically in women copper consumption can cause rheumatoid arthritis which depends on age and food consumption [5]. Due to the cancer in a human body serum copper concentration increase and ceruloplasmin is linked with serum copper. Children basically consumed copper through tap water which gradually causes liver cirrhosis. As we know in the Wilson gene, heterozygote carrier of mutations shows deformity due to high copper consumption which can be a way to develop several liver diseases. In a study shows that, for children if copper level increased 12-62 mg/L it will be responsible for several copper diseases like Indian childhood cirrhosis, idiopathic copper toxicosis and Tyrolean infantile cirrhosis. In case of carcinogenicity copper consumption and breast cancer has no direct link up. The result is the same for lung cancer.

Indium is another element coming from the CIGS panel. It is a group 13 element from periodic table with the melting point 156.60°C and boiling point 2027°C. It is used as an Indium arsenide compound. Due to high consumption of InAs it lowers the body weight and also affect the lung. It causes interstitial fibrosis, inflammation and injury in lung [36]. In an experiment indium oxide is used in rats to measure the toxicity level which shows after a single dose pulmonary toxicity occurred. It also shows carcinogenicity in the body which forms tumors. Indium consumption is done by oral inhale. Fine indium particles are deposited in the lung causes bilateral pneumothorax. Due to long time consumption it causes emphysema and pulmonary fibrosis [37].

Another metal from CIGS thin metallic layer is gallium, which is basically silvery-white in color and comes in group IIIA metal in periodic table. The melting point of gallium is 29.8°C and boiling point is 2204°C. It is used in the panel as a gallium arsenide compound which has a low temperature coefficient and loss very low energy in high temperature. It consists other qualities like low light activity, good moisture and UV resistance, low in weight with good flexibility. Due to those qualities gallium used in many medical applications such as – Gallium nitrate for some microbial infections, bladder cancer, metabolic bone disease. Gallium maltolate is used for lymphoma, microbial infection. During clinical trials in rats for prostate cancer Gallium thiosemicarbazones are used [7]. Although those good qualities, gallium also cause many toxic effects over the environment which directly or indirectly affect the living beings. In humans, as gallium arsenide compound it affects several organs. In the case of reproductive system high concentration of gallium increases abnormal sperm quantity and decreases the sperm motility and at critical level it causes oligospermia. It also causes chronic bronchitis, emphysema and decreases testes weight. Hypoxic pulmonary fibrosis and decreases in the production of sex hormones are also caused due to high consumption of gallium arsenide. According to some experiments gallium also causes tumors in the body and creates complex changes of tubule cells of the kidney [36].

The last and final element of CIGS cell is selenium. It is a group 16 element in the periodic table which melting point is 220.8°C and boiling point is 685°C. Basically it is an important component for cellular function but very poisonous. Due to the overconsumption of selenium it causes hair loss, joint pain, nail brittleness and discoloration, diarrhea, fatigue etc.

6. RECYCLE OF EOL SOLAR PANEL

Now the process of recycling for EOL solar panels is pretty much challenging due to its heterogeneous distribution before transport to the plant like collection, dismantling etc[6]. Different government agencies are agreed to organize some policy to treat the solar waste in a proper manner in almost every country. Like European Government on 2012 formed "Waste of electric and electronic equipment" which is also known as WEEE (European Union Law, 2012) to standardize some particular method for recycling waste panels("Equivalent conditions for the treatment of WEEE exported outside the European Union," 2014). The current problems during recycling of EOL solar panels are each and every panel has very long life span like 20-30 years[14] which gradually reduces the numberof raw waste panels and still now there is no particular technique for recycling with greater efficiency. So at some point there is a huge drawback in case of recycling of solar panel. At the other hand it is already registered that there are many toxic materials like cadmium, lead released from waste solar panels and also loss of precious metals like selenium, gallium, silver etc[14]. So the detection of this toxic through microbial process is a necessity [26]. The main raw material for any basic solar cell is silicon which is used as a poly-silicon material, so scientists are tried to recover silicon from used solar cells and try to produce lead free solar panels using those silicon wafers. Silicon wafers are separated from solar panels using a thermal technique (Ferritic iron-chromium-aluminum alloy for heat) at 480° C. Separated silicon wafers are covered with a phosphoric acid containing etching paste to separate silver and aluminum from wafers. As an alternative of lead, 60Sn-38Bi-2Ag solder is used, this provides the same thermal stability as lead[34]. There are also other types of mechanical or chemical processes are used for used EOL panels. Pyrolysis in a fluidized bed reactor or in a furnace used to separate 100% of glass and 80% of silicon wafers [16]. Ethylene vinyl acetate (EVA) which is basically used in encapsulation of solar cells with the help of a vacuum, to remove this cross-linker pyrolysis process is used under different temperature. Other than a mechanical process, ethylene vinyl acetate(EVA) can also be separated through chemically by using trichloroethyleneat 80°C for 10 days. In earlier days for recycling a chemical process named Deutsche solar recycling process used, which separate 76% of solar cells for further reuse. For a few precious metals in a small lab scale, the residues are separated manually after removing the aluminum plate and junction box [35]. Recovery of glass from used EOL solar panel almost 80-85%, hammer crushing with two blade rotors are used[20]. In the presence of organic solvents by the process of chemical etching, 86% highly purified silicon can be recycled [24]. The recycling of solar panels can be done by different techniques like mechanical, physical or chemical but there also a chance of toxicity due to the use of chemicals. So different biological processes like bioleaching [29] are tried to use to increasing the efficiency of recycling and also reduce environmental pollution [26].

7. CONCLUSION

Presently, all researches are aiming to build up an efficient and economical solar panel with high storage power but their poisonous effects should be kept in mind. After 20-25 years there will be a enormous amount of solar panels are coming out as a waste so that time this green energy source can be a severe issue. If we create some conscious from now on to recycle process or reduce the toxicity from the panels then we do not have to think that time as we think for plastics, fossil fuels or global warming. This article reviews the currently available knowledge on a solar panel with different composition and their lethal consequence, also provides some recycling process. There are different types of solar panels available in the market, all of them have metallic compounds and every metal can cause harmful effect to the environment if consumed ata higher rate. There are many renowned industries manufacturing different solar panels but only a few of them create a special cell for recycling of solar panel. Every country should make some policies to control the solar panel waste and recycle it.

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