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A Review on Recent Advances in Removal of Pollutants from Air

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ABSTRACT

Recently, pollution is one of major factors affecting the environmental condition. This paper provides better solution for removing carbon dioxide , no_x and other solid particulates. By using neem and tusli leaves as absorbing material pollution level of air can reduced. Tulsi protect skin from infection and pollution. Neem can tolerate very high levels of pollution and has the capacity to recover even if most of its foliage is dropped. For improving air quality many researchers suggested different ideas such as using zeolite membrane, Ornamental plants, Peat moss wood, cotton, TIO_2, Noah, Laser absorption technique, adsorption process, activated carbon process etc. But green technology work is one of latest which control pollution and facilates better life for living being on the ground. So using green plants leaves pollution can be minimised. Neem and Tulsi is used for pollutant absorber in this model. both having high potential to resist the pollution and provides better life. Due to these benefits we made a model for pollution control by utilizing tulsi and neem leaves as a pollution controlling materials.

KEYWORDS- Tulsi, Neem, carbon dioxide, air filter**,** air purifier etc.

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INTRODUCTION

Environmental climatic issues facing all over world are recognised as daunting problem for all. Eco- friendly environment is way through we can prevent decline of our environment. Green Plants significance role in monitoring and maintaining the ecological balance by their involvement in the cycling of nutrients and gases like carbon dioxide and oxygen[1]. Green technology enhancing uses renewable sources reduce pollutants, reuse and recycle. Green energy is clean sources of energy that have a lower environmental impact in comparison conventional energy technology[2]. Pytoremediation – using plants to remove pollutants is an cost effective way for improving air quality[3]. Dust particles and volatile organic compounds can pose a risk to health**.** Plants enhance sustainability but underexploited solution to improve indoor air quality[4] . Volatile organic compounds (VOCs) are found in indoor air, which can affect human health (e.g. formaldehyde and benzene). Plants affect the levels of VOCs in indoor environments, thus they represent a potential green solution for improving indoor air quality that at the same time can improve human health[5]. Green roofs is also best innovative technique ,which reduces storm water runoff, , absorb dust and smog, sequester carbon dioxide, produce oxygen, create space for food production, and provide better and natural habitat living being[6] . In this model firstly air filter remove the contaminants from air. This filter also used to remove volatile organic compounds and gaseous substances from the air. Ultimately due to these beneficial work, generated new idea to control pollution by adopting green technology. Neem protect the skin from harmful UV rays ,pollution and other environmental factors. Tulsi gives out oxygen for 20 hours and ozone f four house a day along with the formation of nascent oxygen which absorbs harmful gases like carbon dioxide ,carbon monoxide and sulphur dioxide from environment. This paper focuses on literature of eliminating dust particulate and gaseous pollutants by solid filter.

AIR POLLUTION

It is defined as the presence of toxic chemicals or compounds (including those of biological origin) in the air, at levels that pose a health risk. In other words air pollution means the presence of chemicals or compounds in the air which are usually not present and which lower the quality of the air or cause detrimental changes to the quality of life (such as the damaging of the ozone layer or causing global warming). Air pollution creates unbalanced environment for living being. it is mainly caused by human activities such as construction, transportation, industrial work, agriculture, smelting, residual cooking with low quality of fuels. and cutting of trees. Such substances that contaminate air, water or soil is known as Pollutants.

CLASSIFICATION OF AIR POLLUTANTS :

The air pollutants are classified according to chemical composition. They are further classified according to physical state, that is, gaseous, liquids or solids. Air pollutants are classed according to the manner in which they reach the atmosphere.

1. Primary pollutants: Such pollutants which directly emitted from the source. Primary pollutants are usually produced from a process, such as from volcanic eruptions, CO, SO2, NO2, Pb, Hg, CFCs and NH3.
2. Secondary pollutants : Such pollutants which formed in the atmosphere by chemical interactions among primary pollutants and normal atmospheric constituents. Smoke is secondary types of pollutants.

Air pollution is judged by the presence of five important components : Oxides of Sulphur, Suspended Particulate Matter, Oxides of Nitrogen, hydrocarbons and oxides of carbon.

Motor vehicle have been regarded as the primary cause of air pollution in the urban areas and account for 60 to 70% of the pollution found in the urban environment. SO2, NO2, SPM and RSPM are major air pollutants in India[7]. Most of sources of air pollution are related to human‘s activities as a result of the modern life style. Depletion of ozone layer is also caused by air pollution. Governments and health organizations have implemented various rules & regulations to reduce air pollution levels for the protection of human health. The WHO assessed air pollution data from more than 3000 cities worldwide and found that half of the cities in high-income countries and one third of those in low- and middle-income countries reduced air pollution levels by more than 5% between 2011 and 2018[8]. Recent times pollution level is widely increasing all over world. The aim of the present review is to provide insight into how herbal leaves can be effectively utilised in reducing the air pollution.

MAJOR AIR POLLUTANTS IN THE ENVIRONMENT, POLLUTANT SOURCES AND THEIR EFFECT ON PUBLIC HEALT

Sr. No.	Outdoor pollutant	Pollutant sources	Health problem
1.	Carbon Monoxide	Burning wood, diesel and petroleum	Enhances confusion, sleepiness, low blood oxygen level, slow reflexes
2.	Carbon dioxide	Burning coal, oil, and natural gases	Lowers oxygen levels, vision defects, reduces respiratory and brain functions,
3.	Nitrogen dioxide (NO2)	Burning fuels, electricity generation plus vehicle engines,	defect in lung function and causes bronchitis in asthmatic children, toxic
4.	Sulphur dioxide (SO2)	industrial processes, and Burning fossil fuels	eye irritation and respiratory inflammation, asthma attacks,, mucus secretion, decreases pulmonary function.
5.	Ozone (O3)	photochemical smog produced by the interaction of sunlight and air pollutants	breathing difficulties and asthma, colds, pneumonia
6.	Suspended particulate matter (PM10, PM2.5, SPM)	Mixture of solid and liquid organic plus inorganic materials including nitrates, sulphate, carbon, sodium chloride, ammonia, mineral dust and water	Disrupts lung‘s gas exchange function and respiratory illness

CONTROL OF AIR POLLUTION:

Indoor air pollution from solid fuel use and urban outdoor air pollution are estimated to be responsible for 3.1 million premature deaths worldwide every year and 3.2% of the global burden of disease . Due to continuous level of increasing pollution , ecosystem is directly unbalanced. Plants continue to function as atmospheric filters indoors as they do outdoors and enhance the air quality of confined environments. In addition to finding a reduction in particulate matter it was also found that relative humidity was slightly higher when plants were present. For improving air quality many researchers suggested different ideas such as using zeolite membrane .peat moss wood, cotton, TIO_2, Naoh, Laser absorption technique, adsorption process, Activated carbon process etc .But green technology work is one of latest which control pollution and facilates better life for living being on the ground, which is eco- friendly in nature. For improving indoor air quality some researchers

suggested that utilization of horticulture and biotechnological tools[9]. Some suggested that TIO_2 material is best which absorbs pollutants with high removal rate. The destruction of aromatic compounds are nearly 100%. This material easily enhancing removal rate of pollutants[10,11,12]. But cost of TIO_2 is expensive. For treating air adding ozone enables increases the efficiency but increases reactor size[13]. Primary technique used to remove carbon dioxide in space life was lithium hydroxide . It deals about sorvent easily removed low concentration under ambient pressure and temperature[14]. Volatile organic compounds are most common air pollutants emitted from petrochemical, chemical and allied industries. It is necessary to limit and control emissions because they affect the change of climate, growth and decay of animal plants and health of other living being. Adsorption has good removal techniques but having higher capital investment and operating conditions[15]. Elimination of carbon dioxide was done by a cartridge filled with Naoh during desorption process. Main advantage of plasma is measures light gases and permanent gases. But for beter accuracy a lot of work is needed in this field[16]. Recently, the development of new micro porous materials for adsorption processes is rapidly increasing. new metal framework(MOFs) are other porous coordinated polymers are being generated at rapid rate. Due to high pollution rate the concentration of carbon dioxide in the atmosphere has increased rapidly. Most widely adopted approach is adsorption with aqueous ammine solution (eg;- monoethanol). It is concluded that several correlations between the adsorption of carbon dioxide and absorbent but no correlations with purely structure of properties such as pore size , so finds better material for carbon dioxide separation[17]. Polymer membrane system is also acts as a filter to separate one or more gases from a feed mixture and generates a specific gas .Polymer membrane achieves better permeability, but it should cheap and processed into hollow fibre formet. Hence polymeric membrane will remain active in research[18]. Plasma – catalyst coupling is best techniques to control indoor air problem. Carbon dioxide is also controlled by this techniques, which is main combustion product from gas , kerosene, and wood coal filled appliances. Adsorption play main role in this techniques, adsorption is mainly two types, Physiosorption and Chemisorptions. The key of this research is such technologies is coupling with the catalytic[19]. This is best innovative techniques for pollution control. Authors suggested that next few years focus on different types of catalysts able to achieve together a good vocs adsorption. The multi flue gases (CO_2, SO_2 ,NO_2) can be absorbed in the aqueous ammonia instead of removing so_2 and no_2 first of carbon dioxide capture by monoethanolamine. Lots of pilot scale and industrial demonstration ammonia based post combustion capture system have been constructed in recent year. Which is the best way to reduce co_2 emission for the fossil fuel power plants. Heat transfer varies little with ammonia flow rate and its concentration , as well as inlet carbon dioxide volume and fraction and temperature, but increases with inlet liquid temperature and

flow rate[20]. Zeolite membranes can be used successfully to remove volatile particles from indoor at very low concentration level. It works in better way for removal of vocs at low concentration level[21]. Some researcher focuses on the synthesis and the absorbing properties of variety of porous sorbent materials that have been studied for application of removal of organic, particularly in the area of oil spill cleanup. The discussion is especially focused on silica areogels, zeolites, organoclays and natural sorbents. For better efficiency a lot of research is remain in this field[22]. One of best possibilities to separate particles with difficult dust properties from gas. Widely used separating techniques for particles from streams are cyclones, scrubbers filters and electrostatic precipitators. Dust particles are difficult to handle when the flux density of the particles to collecting surface is low and mixtures of solid and liquid particles do occur. It is concluded that there is variety of solutions to separate soild and liquid having difficult dust properties. So by looking fundamentals of dust particle separation new ideas can found[23]. A large number of researches is done on properties of carbon dioxide selective membranes based upon inorganic materials such as alumina, zeolite, carbon and silica. Electrochemical membranes have best capability to economically separate carbon dioxide from flue gas. Chemical looping is also best best method of carbon dioxide separation. Preliminary cost analyses of chemical looping is very promising for capture of carbon dioxide. It is concluded that target target carbon dioxide capture technologies were compared for different level of development. Future research will enhance projected energy efficiencies[24]. Air fuel ratio is very important for control exhaust emissions. One of best technique is the use of spark plug as a combination sensor, which controls emission in better way. Recently, fuel economy and reduction of harmful emissions is two critical need of automotive engine design. Three way catalytic converters is used for converting exhaust gas into less toxic product[25]. Due to conventional cooling system large amount of carbon dioxide gas released , which is harmful our ecosystem and produced green house effect. This paper carried out in order to find new cooling system which is free from pollution effect. This reviews on new cycles namely the hybrid and desiccant and by development of rotating device for increasing heat and mass transfer . These technologies also reduce the energy cost and installation cost as well as negative impact on environment . Some of innovation are still in research such as using solar energy for refrigeration[26]. Ventilation is the primary mechanism for maintaining indoor air quality. Increasing ventilation rate can improve indoor air quality. It is important to maintain relationship between geometric room parameters and air flow patterns produced by mechanical ventilation systems. An alternative solution is to improve efficiency of ventilation system enhance in ventilation rates and energy consumption are minimal. Simulation are performed with CFD software fluent. It is conculded that all the simulations predict the measured trend in model room very well, with relative error never much larger than 20% value[27]. Spectroscopic device is best device for

optical monitoring of climate pollutants. Methane and black carbon are major product in form of pollutants, which leads green house effect. Carbon dioxide is responsible for 55-60% of current pollution level. This techniques increases exciting optical power and highly appropriate for application in harsh environment[28]. Due to heavy traffic carbon dioxide emission is continuously increasing over the world. The target of European union is reducing green gas emission by 20% between 1990 and 2020. Paper deals with various carbon emission techniques .Best methodology of emission reduction is reduction of road traffic volume , which involves increasing parking fees and establishing park and ride facilities and more bicycle lanes to promote physical activity. Another way of emission control is reduction of road traffic emissions, which involves utilization of electric cars having zero emission[29]. Recently temperature and humidity control is major task for air conditioning system. . Indoor air pollution from VOCs is produced daunting effect for human health. Removal of chemical pollutants depended on solubility of different liquid desiccant. Therefore , an additional benefit of LDAS is that it can remove a certain amount of VOCs to certain degree during the dehumidification process[30]. There are also various techniques available for reduction in emissions. The mitigation techniques were a spraying water- oil mixture and recalculating air scrubber. Water- oil bath spraying and air scrubber system have the advantage of reducing both ammonia and PM concentrations. No negative effects of the water-oil mixture aerosol particles were detected in the animal lungs .Author concluded that further study is needed on pollutants mitigation in different animals bars to optimize its application for better effects[31]. Climate and air quality is major issues in recent times. Black carbon from combustion processes, scatters and absorb solar radiation. These contributes to poor air quality , induces respiratory and other health problems. Black carbon is an important atmospheric pollutants. It produces a hazard to human life in two ways having the potential to affect both our climate and our health. BC is abundant in lower region of atmosphere. Most effective way of regulating the emissions of BC is to include the climate effects in the design of regional air quality regulations. Black smoke monitoring needs only a pump and a filter holder. At the other extreme , the increasing use of satellite data alone or in combination with other data will provide much greater coverage for the global[32]. Indoor air pollution is one of most serious problem for human health. People spend their maximum time in indoor environments such as offices, public buildings and residences. Indoor air pollutants level is several hundreds times higher than outdoors. Environment have changed rapidly due to maximum use of laser- jet printers and ink-jet printers. The extensive use of modern equipment giving rise to health effects such as headache, mucous irritation and dryness in the eyes, nose and throat. Laser printers use heat and pressure to fix image on paper. Ozone is generated from corona wires. Reducing fuser temperature may result in lower emissions[33]. Polluted air has been increasing major issue for environmental and

health concern. In recent year, biological techniques have been applied frequently to overcome on these emissions. Different waste gases require different strategies for optical purification. Biological treatment provides an opportunities for economical and environmental eco –friendly solutions for many waste gas emissions. bio filters can eliminate the same types of volatile compounds except ammonia[34]. Phytoremediation – using plants to remove pollutants as an attractive and effective way of improving indoor air quality. Cooking and smoking is also affect quality of air. benzene causes anaemia, cancer and leukaemia. Benzene can also enhancing the frequency of chromosomal aberrations. Indoor air quality can be improved by mainly three ways: controlling source, cleaning air and designing ventilation system to exhaust. Domestic and agriculture pollutants increasingly viewed as major threats to both terrestrial and aquatic ecosystems. Mechanism used for N removal in VDD plants include plant uptake , transformation sedimentation, volatilization, microbial assimilation[35]. Cleaner production is new innovative techniques in handling wastes and pollutants in industries. Pollution is mainly increasing due to utilization of energy by power plants, automobile sector and other industrial sector. Pollution level is enhancing due to utilization of old technologies, hence low level of energy obtained. This paper deals that best techniques for emission control. Renewable energy is best way for reduction of air pollution. Researcher suggested seven steps for cleaner production of energy. These are as ;Integrated pollution prevention and control, Interrelation between energy ,environment and climate, Bench mark , Internal and external factors, capacity building, Technology transfer, Financial packing. This is most efficient way for cleaner production of green energy[36]. Ultimately we find that a lot of scope is in air purification by adopting green technology.

CONCLUSION

Many researchers provides different ideas for control of pollution. This innovative ideas can play important role in control of air pollution. Due to significance work of tulsi and neem leaves used these as pollutant material. Green technology in one of recent technology which controls pollutions and provides significance role for better environment. Hence these green plants plays better role in air pollution control. Cost problem of air purifier can also reduced. In present time pollution level over earth is most environmental problem, which highly affecting life on ground. Plants gives oxygen which is necessary for life and minimize level of pollution by absorbing carbon dioxide. Material taken in this paper having less cost and no any side effect. Various researchers taken different materials such as active carbon, zeolite, Naoh, TIO_2 etc. For removal of pollutants. But Using green plants in pollution control is one of better innovative ideas. So it would better to make eco-friendly air purifier which having significant result. Ultimately this would be one of best

purifier which easily controls pollution and provides better life on the earth. There is a lot of scope in air purification on herbal plant.

REFERENCES:

1. Reshma, V. S., Prashant Kumar, and G. S. Chaitra. "Significant Role of Ornamental Plants as Air Purifiers–A Review." *Int. J. Curr. Microbiol. App. Sci* 2017; 6(8): 2591-2606.
2. Bhowmik, Chiranjib, et al. "Optimal green energy planning for sustainable development: A review." *Renewable and Sustainable Energy Reviews* 2017; 71: 796-813.
3. Liu, Yan-Ju, et al. "Which ornamental plant species effectively remove benzene from indoor air?." *Atmospheric Environment* 2007; 41.3: 650-654
4. Brilli, Federico, et al. "Plants for Sustainable Improvement of Indoor Air Quality." *Trends in plant science* 2018.
5. Cruz, Majbrit Dela, et al. "Can ornamental potted plants remove volatile organic compounds from indoor air?—a review." *Environmental Science and Pollution Research* 2014; 21.24 :13909-13928.
6. Li, Yanling, and Roger W. Babcock. "Green roofs against pollution and climate change. A review." *Agronomy for Sustainable Development* 2014;34.4:695-705.
7. Conti, Gea Oliveri, et al. "A review of Air Q Models and their applications for forecasting the air pollution health outcomes." *Environmental Science and Pollution Research* 2017; 24.7 :6426-6445.
8. Requia, Weeberb J., et al. "Global Association of air Pollution and Cardio respiratory Diseases: a systematic review, meta-analysis, and investigation of modifier variables." *American journal of public health* 2018; 108.S2: S123-S130.
9. Irga, P. J., T. J. Pettit, and F. R. Torpy. "The phytoremediation of indoor air pollution: a review on the technology development from the potted plant through to functional green wall biofilters." *Reviews in Environmental Science and Bio/Technology* 2018; 1-21 .
10. Ao, C. H., and S. C. Lee. "Combination effect of activated carbon with TiO2 for the photo degradation of binary pollutants at typical indoor air level." *Journal of Photochemistry and Photobiology A: Chemistry* 2004; 161.2-3 : 131-140.
11. Sarria, Victor, et al. "An innovative coupled solar-biological system at field pilot scale for the treatment of bio recalcitrant pollutants." *Journal of Photochemistry and Photobiology A: Chemistry* 2003;159.1:89-99.

12. Jo, Wan-Kuen, Jung-Hoon Park, and Hee-Dong Chun. "Photocatalytic destruction of VOCs for in-vehicle air cleaning." *Journal of Photochemistry and Photobiology A: Chemistry* 2002; 148.1-3 : 109-119.

13. Pichat, P., et al. "Purification/deodorization of indoor air and gaseous effluents by TiO2 photocatalysis." *Catalysis today* 2000; 63(2-4): 363-369

14. Satyapal, Sunita, et al. "Performance and properties of a solid amine sorbent for carbon dioxide removal in space life support applications." *Energy & Fuels* 2001; 15(2) :250-255.

15. Khan, Faisal I., and Aloke Kr Ghoshal. "Removal of volatile organic compounds from polluted air." *Journal of loss prevention in the process industries* 2000; 13(6):527-545

16. Chan, Qilin, and Joseph A. Caruso. "Plasma-based gas chromatography detectors." *Gas Chromatography*, 2012;1.

17. Bae, Youn-Sang, and Randall Q. Snurr. "Development and evaluation of porous materials for carbon dioxide separation and capture." *Angewandte Chemie International Edition* 2011; 50(49) :11586-11596.

18. Kentish, Sandra E., Colin A. Scholes, and Geoff W. Stevens. "Carbon dioxide separation through polymeric membrane systems for flue gas applications." *Recent Patents on Chemical Engineering* 2008; 1(1): 52-66.

19. Thévenet, Frédéric, et al. "Plasma–catalyst coupling for volatile organic compound removal and indoor air treatment: a review." *Journal of Physics D: Applied Physics* 2014; 47(22): 224011.

20. Chu, Fengming, Yifang Liu, Lijun Yang, Xiaoze Du, and Yongping Yang. "Ammonia escape mass transfer and heat transfer characteristics of CO2 absorption in packed absorbing column." *Applied Energy* 2017; 205: 1596-1604.

21. Aguado, Sonia, et al. "Removal of pollutants from indoor air using zeolite membranes." *Journal of Membrane Science* 2004; 240(1-2): 159-166.

22. Adebajo, Moses O., et al. "Porous materials for oil spill cleanup: a review of synthesis and absorbing properties." *Journal of Porous materials* 2003; 10(3): 159-170

23. Peukert, W., and C. Wadenpohl. "Industrial separation of fine particles with difficult dust properties." *Powder Technology* 2001; 118(1-2): 136-148.

24. Granite, Evan J., and Thomas O'Brien. "Review of novel methods for carbon dioxide separation from flue and fuel gases." *Fuel Processing Technology* 2005; 86.(14-15):1423-1434.

25. Walters, S. D., M. M. De Zoysa, and R. J. Howlett. "Monitoring the air–fuel ratio of internal combustion engines using a neutral network." *Measurement Science and Technology* 2006; 17(10):2773.

26. Afonso, Clito FA. "Recent advances in building air conditioning systems." *Applied Thermal Engineering* 2006; 26(16): 1961 - 1971.

27. Posner, J. D., C. R. Buchanan, and D_ Dunn-Rankin. "Measurement and prediction of indoor air flow in a model room." *Energy and buildings* 2003; 35(5): 515-526.

28. Wang, Gaoxuan, et al. "Laser absorption spectroscopy applied to monitoring of short-lived climate pollutants (SLCPs)." *Journal of Molecular Spectroscopy* 2018; 348: 142 - 151.

29. Keuken, M. P., et al. "Impact on air quality of measures to reduce CO2 emissions from road traffic in Basel, Rotterdam, Xi'an and Suzhou." *Atmospheric environment* 2014; 98: 434 - 441.

30. Fu, Huang-Xi, and Xiao-Hua Liu. "Review of the impact of liquid desiccant dehumidification on indoor air quality." *Building and Environment* 2017; 116: 158-172.

31. Mostafa, Ehab, et al. "Evaluation of two indoor air pollution abatement techniques in forced-ventilation fattening pig barns." *Atmospheric Pollution Research* 2017; 8(3): 428 - 438.

32. Highwood, Eleanor J., and Robert P. Kinnersley. "When smoke gets in our eyes: The multiple impacts of atmospheric black carbon on climate, air quality and health." *Environment International* 2006; 32(4): 560-566.

33. Lee, S. C., Sanches Lam, and Ho Kin Fai. "Characterization of VOCs, ozone, and PM10 emissions from office equipment in an environmental chamber." *Building and Environment* 2001; 36(7): 837 - 842.

34. Van Groenestijn, J. W., and N. J. R. Kraakman. "Recent developments in biological waste gas purification in Europe." *Chemical Engineering Journal* 2005; 113(2-3): 85-91.

35. Kumwimba, Mathieu Nsenga, et al. "Removal of non-point source pollutants from domestic sewage and agricultural runoff by vegetated drainage ditches (VDDs): Design, mechanism, management strategies, and future directions." *Science of The Total Environment* 2018; 639 :742-759.

36. Visvanathan, C., and S. Kumar. "Issues for better implementation of cleaner production in Asian small and medium industries." *Journal of Cleaner Production* 1999; 7(2): 127-134.