International Journal of Engineering & Technology, 8 (1.10) (2019) 159-166

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A Literature Review on Effective Monitoring of NOx Pollutants Using Environmental Wireless Sensor Networks (EWSN)

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Abstract

Environmental Sensor Networks (ESNs) support the examination of fundamental methods and the progression of peril response structures. They have progressed from confined logging structures that require manual downloading, into 'smart' sensor composes that include an arrangement of customized sensor centers and exchanges systems which viably confer their data to a Sensor Network Server (SNS) where these data can be consolidated with other natural datasets. Implementation of stringent controls of NOx outpouring requires the change of new headways for NOx removal from drain gases. As a rule, the data recommend that fashioners respond to biological managerial weight in their own country, anyway, not to remote common controls. Furthermore, any development trade that happens appears, from every angle, to be meandering.

***Keywords**: NOX, Environmental Sensor Network, Pre and Post Ignition, Coal Power Plants.*

1. Introduction

Ongoing advances in remote interchanges and hardware have brought the vision of Wireless Sensor Network (WSN) into reality which have expanded the development of minimal effort, low power and multi-practical sensors that are little in measure and can impart in short range. Every hub comprises of microcontrollers, memory and handset. The microcontrollers are utilized to execute errand, information handling and help the usefulness of different parts in the sensor hub. For the memory, it is principally utilized for information stockpiling while the handset demonstrations from the blend of transmitter and recipient capacities [1].

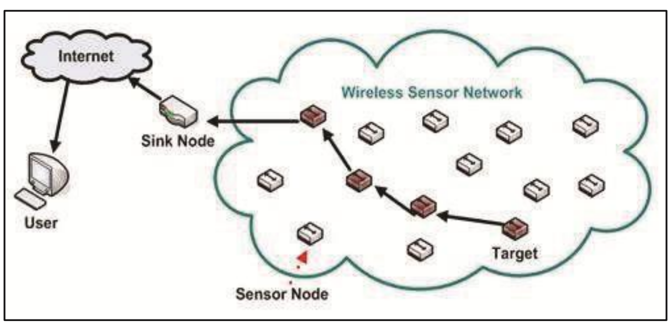

Fig.1: Wireless Sensor Network

Fig 1. demonstrates the Wireless Sensor Network engineering that is connected in natural observing which contains sensor hubs, client and sink hub. Sensor hubs will speak with each other and transmit the handled information to sink hub over a remote correspondence. Sink hub gathers information from every one of the hubs and transmits the dissected information to client by means of Internet [2].
Common marvels information, for example, temperature, light, solid and weight are gathered by sensors and after that transmitted to a server. These batteries fueled hubs are utilized to screen and control the physical condition from remote areas. In the previous couple of years, the uses of Wireless Sensor Network have been broadly utilized and connected in therapeutic, military, mechanical, agrarian and natural observing.

For as long as couple of years, Wireless Sensor Network has been connected in different fields and generally in condition observing applications. Ecological checking is the principle independence which may contribute expansive impacts. The shaky climate conditions as of late showed how imperative a profound comprehension of our environment and its advancement is for individual.

1.1. Air Contamination and Nox

Although the wellbeing impacts of long haul introduction to air contamination are entrenched, it is hard to successfully impart the wellbeing dangers of this (to a great extent undetectable) chance factor to general society and strategy creators. The reason for this examination is to build up a technique that communicates the wellbeing impacts of air contamination in an equal number of day by day latently smoked cigarettes.

Techniques: Defined changes in PM2.5, nitrogen dioxide (NO2) and Black Carbon (BC) fixation were communicated into number of inactively smoked cigarettes, in view of proportional wellbeing dangers for four result measures: Low Birth Weight (2500 g at term), diminished lung work (FEV1), cardiovascular mortality and lung disease. To depict the quality of the association with ETS and air poisons, we outlined the epidemiological writing utilizing distributed or new meta-investigations [3].

Results: Realistic augmentations of 10 mg/m3 in PM2.5 and NO2 focus and a 1 mg/m3 augment in BC fixation relate to by and large (standard mistake in enclosures) 5.5 (1.6), 2.5 (0.6) and 4.0 (1.2) latently smoked cigarettes every day over the four wellbeing endpoints, individually. The vulnerability reflects contrasts in proportionality between the wellbeing endpoints and vulnerability in the fixation reaction capacities. The wellbeing danger of living along a noteworthy road in Amsterdam is, contrasted with a counterfactual circumstance with 'clean' air, proportionate to 10 every day inactively smoked cigarettes.

Determinations: We built up a technique that communicates the wellbeing dangers of air contamination and the medical advantages of better air quality in a straightforward, engaging way. The strategy can be utilized both at the national/local and the nearby level. Assessment of the value of the technique as a specialized device is required.

SOURCES OF NOX

In 2007 aggregate nitrogen oxides discharge in Poland achieved 890 Gg, as far as NO2 this was 50 Gg more than in 2000 (Central Statistical Office, 2009). This is essentially a result of intensity plants and vehicles, Fig. 2. Following the promotion to the EU, Poland consented to diminish the emanation furthest reaches of NOx underneath 200 mg/m3 after 2015 (Dora et al., 2009) [4].

Worldwide offers of NOx anthropogenic sources are like those saw in Poland. Referred to after Elzey et al. (2008) the essential wellsprings of NOx emanation incorporate engine vehicles (55%) and modern, business ignition forms (45%). Expanded ignition of petroleum derivatives since the most recent century has been an essential wellspring of NOx, prompting the expansion of poisons focus in the air. Be that as it may, different wellsprings of NOx, for example, the creation and utilization of nitric corrosive ought not be disregarded. Amid nitric corrosive plant activity and nitrification and oxidation of natural mixes with the utilization of nitric corrosive, nitrous gases in fluctuating focuses are shaped (Dyer Smith and Jenny, 2005).

NOx produced from cremation forms comprise in 95% of NO nitric oxide and 5% NO2 nitrogen dioxide (Gomez-Garcia et al., 2005; Van Durme et al., 2008; Wang et al., 2007). In this manner, nitrogen dioxide shaped in the environment through the photochemical oxidation of nitric oxide is an auxiliary poison. In any case, it has been demonstrated that for portable wellsprings of NOx the offer of NO2 essential discharge may be variable. Besides, it is subject to the vehicle compose, and states of task (Carslaw and Beevers, 2004). Kartenbuch et al. (2001) performed tests evaluating the measure of essential NO2 discharged from oil, diesel vehicles and diesel trucks [5]. They got NO2/NOx blend proportion of b0.2 vol.%, 5.9 vol.% and 11.0 vol.% for oil, diesel vehicles and diesel trucks, separately. Though, nitrous oxide N2O other than being created in ignition procedures of non-renewable energy source and biomass is likewise transmitted from substance industry exercises, for example, adipic corrosive generation for Nylon 6.6 and nitric corrosive make.

Common wellsprings of NOx, regardless of not being as pivotal as anthropogenic ones, are yet worth posting: oxidation of NH3, lightning, and fountain of liquid magma exercises [6].

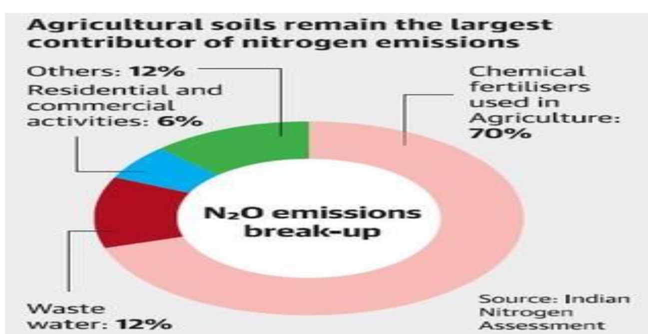

Fig. 2: Nitrogen oxides outflow 2011.

1.2. Impacts of Nox

a. NOX Post Burning

NOX emanations can be controlled by means of adjustments to the burning procedure or by treatment of pipe gas after ignition. The essential post-ignition methods are specific reactant diminishment (SCR) and particular non-synergist decrease (SNCR). SCR has a higher capital cost than SNCR yet can decrease emanations by as much as 80– 90%, contrasted with only 30– 40%reduction from SNCR innovations [7].

Table 1: Summary Of No_x Control Techniques Used At Coal-Fired Power Plants

	US	%	Germany	%	Japan	%
Total number of plants	1150		228		87	
Combustion modification only	415	36.1	68	29.8	22	25.3
Use post-combustion	44	3.8	118	51.8	51	58.6
Of these Post-combustion only	22	1.9	27	11.8	6	6.9
Both	22	1.9	91	39.9	45	51.7

The table shows the total number of coal-fired power plants reported in the CoalPower4 database as of 2000, as well as the number of plants using each type of NO_X control technique. For those plants using post-combustion techniques, the last rows indicate whether they use post-control techniques alone or in tandem with combustion modification.

In that capacity, SCR is the innovation of decision for plants confronting tight NOX emanations limitations, for example, in Germany and Japan. Table 1 demonstrates the quantity of plants utilizing post-burning procedures versus those utilizing ignition adjustment, taken from the CoalPower4 database. This database, accessible from the International Energy Agency's Clean Coal Center, incorporates coal-let go plants in task starting at 2000. While the dominant part of Japanese and German coal-let goes plants utilize post-ignition strategies, only 44 post-burning treatment methods were being used in 1150 US units (3.8%) [8].

2. Part of Ewsn's in Observing Nox

What is an Environmental Sensor Network?

An Environmental Sensor Network involves a variety of sensor hubs and an interchanges framework which enables their information to achieve a server Fig. 5. The sensor hubs accumulate information independently and an information organize is generally used to pass information to at least one base stations, which forward it to a Sensor Network Server (SNS). A few frameworks send summons to the hubs keeping in mind the end goal to bring the information, while others enable the hubs to send information out self-ruling [9] [10].

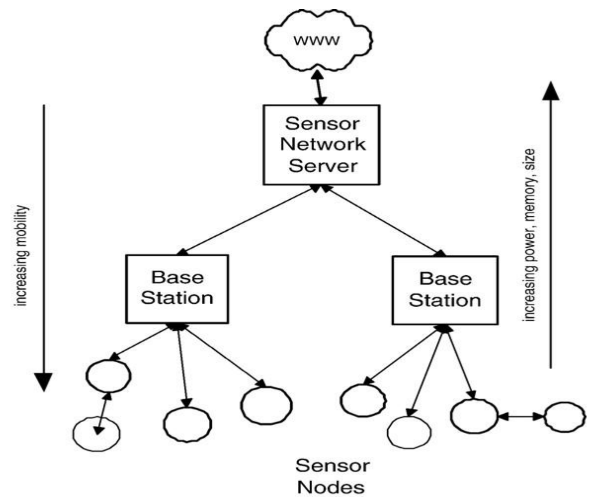

Fig. 5: Schematic diagram showing the different parts of an Environmental Sensor Network.

Sensor systems can be wired together, and there are various extremely critical ventures (especially those submerged) that utilization this technique (e.g. Leo-15 Coastal Cabled Observatory — Glenn et al., 2006; NEPTUNE venture — Phibbs and Lentz, 2006). Be that as it may, for some applications the point is to move towards remote sensor systems, as links are frequently unrealistic, prominent and can exasperate nature being observed. Where the sensor hubs powerfully intercommunicate with a specific end goal to set up a system this is named a specially appointed system. Diverse kinds of information are gathered by the sensor hubs. This incorporates application particular ecological parameters and in addition nonexclusive information, for example, meteorological or differential Global Positioning System (dGPS). This information can be in various structures, computerized and simple, spatial and transient, alphanumeric or picture, settled or moving. At the SNS level the information can be imagined and broke down inside a Geographic Information System (GIS), joined with a satellite picture or potentially delineate, distributed through the Web to give clients consistent access to data.

Climbing the chain of command from sensor hubs through to the Sensor Network Server the frameworks by and large increment in computational power, information stockpiling and power accessibility. The sensor hubs can store information, settle on choices about what information to pass on (e.g. neighborhood) and even settle on choices about when and what to detect (when conditions are proper). The versatility of sensor hubs or base stations might be high and require area frameworks. In the event that an extensive number of sensor hubs are required then they would regularly be sorted out as a specially appointed arrangement of bunches with agent hubs conveying a gathering's information to base stations. There may likewise be intercommunication between the SNS and sensor hubs (process reaction), e.g. on the off chance that an oil slick happens or climate estimate recommends a tempest will happen then the hubs can switch on or change their conduct.

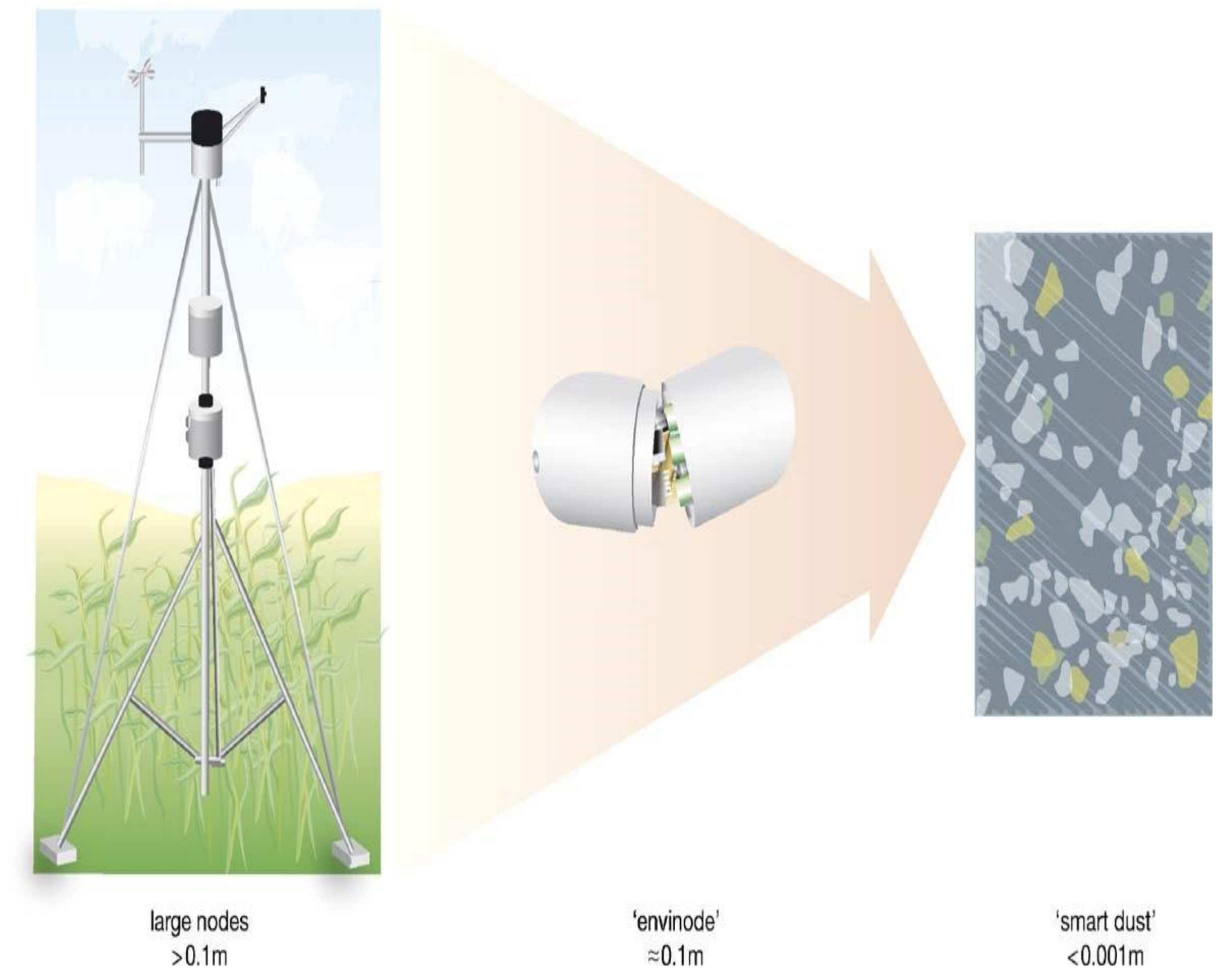

Fig. 6: Schematic diagram to show the scales of sensor nodes from large scale fixed nodes.

Table 2: Some Examples Of Different Environment Sensor Network; Their Type, Sensors And Scale

Example	Type of ESN	Sensors	Scale
Global Seismographic Networkhttp://www.iris.edu	Large Scale Single Function Network — seismology	Seismometer accelerometer	Global
The Georgia Automated Environmental Monitoring Network http://www.georgiaweather.net/	Large Scale Single Function Network — weather	Meteorological data	Regional
Web based hot spot modelling using GEOS http://goes.higp.hawaii.edu/	Large Scale Single Function Network — remote sensing	Multispectral imaging	Pacific rim and USA
Deep-ocean Assessment and Reporting of Tsunamis (DART) http://www.ndbc.noaa.gov/dart.shtml	Large Scale Single Function Network — tsunamis monitoring	Oceanographic and meteorological data+bottom pressure recorders	
SNOTEL http://www.wcc.nrcs.usda.gov/ snotel/snotel-info.html	Large Scale Single Function Network — snow depth sensing	Snow thickness	Regional
National Science Foundation Polar UV Monitoring Network http://www. biospherical.com/NSF/default.asp	Large Scale Single Function Network — UV monitoring	UV	Polar regions
The Pacific Northwest Seismograph Network http://www.pnsn.org/welcome.html	Large Scale Single Function Network — Seismology	Seismic sensors	Regional
5 seismic projects http://www.cens.ucla.edu	Large Scale Single Function Network — seismology	Seismology	100 m–regional
Tropical Atmosphere Ocean Project http://www.pmel.noaa.gov/tao/index.shtml	Large Scale Single Function Network — oceanography	Oceanographic and meteorological data	
King County Lake Data http://dnr.metrokc.gov/wlr/waterres/ lakedata/index.htm	Localised Multifunction Network — water quality	Weather, pH, conductivity, dissolved oxygen, chlorophyll	Local
Onondaga Lake Improvement Programme http://waterontheweb.org/data/onondaga/	Localised Multifunction Network — water quality	Temperature, dissolved oxygen concentration, salinity	Local
Olentangy River Wetland Research Park http://swamp.ag.ohio-state.edu/	Localised Multifunction Network — water quality	Weather, hydrodynamic sensors, webcam	Local
Ipswich-Parker Suburban WATershed Channel http://www.ipswatch.sr.unh.edu/index.html	Localised Multifunction Network — water quality	River flow, quality, precipitation, estuarine depth and quality, weather	Regional

8+ habitat sensing projects http://www.cens.ucla.edu	Localised Multifunction Network — habitat monitoring	Microclimate, video camera, with soil respiration (CO_2), nutrient flux (N, P, etc.)	100 m–1 km
Great Duck Island http://www.greatduckisland.net/	Localised Multifunction Network — habitat monitoring	Temperature, light, humidity	>100 m
Huntington Gardens http://www.sensorwaresystems.com	Localised Multifunction Network — habitat monitoring	Light levels, air temperature and humidity, soil temperature and soil moisture	1 km
Tucson Flooding Project http://www.sensorwaresystems.com	Localised Multifunction Network — habitat monitoring	Ambient air temperature, relative humidity, and light level. soil moisture	1 km

3. Cases of Environmental Sensor Networks

Natural Sensor Networks shift in their scale and capacity. Since the point of an ESN is to naturally detect the earth, we have taken an exceptionally expansive view on what includes such a system. Here we portray the properties of some unique kinds of frameworks, which are abridged underneath and in above Table 2 and Fig. 7. This rundown is in no way, shape or form far reaching, however shows a scope of more than 50 current illustrations [11] [12].

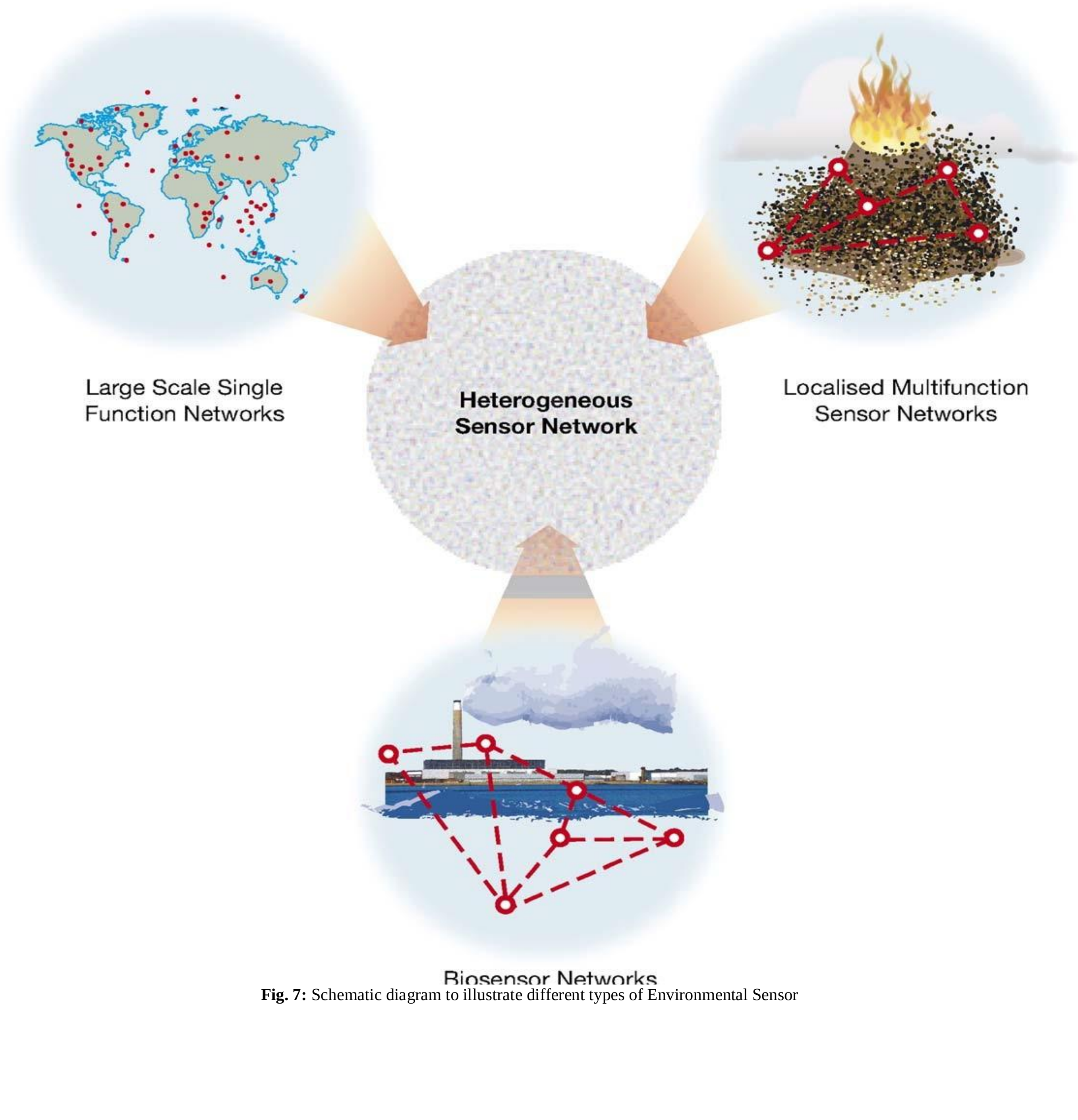

Fig. 7: Schematic diagram to illustrate different types of Environmental Sensor

4. Literature Survey-Table 3.

Sl.no	Title & Publication details	Author(s)	Contribution/s	Limitations
1	Case study: monitoring of air quality in king faisal university using a microcontroller and wsn Published by- Elsevier ProcSci Year- 2013	Qasem abu al-haija, hasan al-qadeeb and abdulmohsen al-lwaimi	It gives a constant data about the level of air contamination in various areas, and in addition give alarms in instances of extreme change in nature of air.	The circuit can be enhanced to gauge the level of different gases noticeable all around such sulfureted hydrogen (h2s), ammonia (nh3), alcohol and numerous others.
2	The importance of including carcinogenic benzene in real-time ambient air quality data in delhi Published by- COMSNET IEEE Year- 2016	Nancy Agrawal Arushi baboota	The sensor in view of gold nanoparticles and carbon nanotubes gives off an impression of being the most suitable choice in light of its details.	Photoionization detectors (pids) – pids are not completely selective towards the detection of benzene as they are sensitive towards other gases and other vocs too.
3	Wireless sensor network applications: a study in environment monitoring system Published by-Elsevier PrcoSci Year- 2012	Mohd fauzi othman, khairunnisa shazali	This paper audits the remote sensor organize applications which center for the most part around the ecological observing framework.	Real mishap is identification in modern zones must be finished.
4	Air pollution in perspective: health risks of air pollution expressed in equivalent numbers of passively smoked cigarettes Published by-Elsevier Environmental Research Year-2016	Saskia c. Van der zee, paul h. Fischer, gerard hoek	Authors have built up a strategy to express the wellbeing impacts of air contamination into proportionate measures of detached smoking, in light of the as of now accessible epidemiologic confirmation.	Another critical wellspring of vulnerability is the presumption of the everyday measure of cigarettes that a smoker smokes inside at home.
5	Passive samplers for nox monitoring: a critical review Published by-Academic Publisher Netherlands Year-2003	C.k. varshney, abhai pratap singh	This paper presents a comprehensive review including, historical development and critical assessment of validation studies along with comparison of both badge and tube type passive samplers.	This paper doesn't manage the dynamic samplers and constant qualities.
6	Prediction of nox concentration from coal combustion using ls-svr Published by- IEEE Trans Year-2010	Ligang zheng, hailin jia, shuijun yu, minggao yu	The ls-svr display gives the other option to bpnn and grnn demonstrate.	This paper has the limited predictive precision over grnn

5. Abatement of Nox

5.1. NOx decreases techniques for modern and general power plants

On account of cremation forms happening in control stations three ways to deal with reduction of NOx emanation are known: pre-combustion, ignition alteration and post-burning systems which are additionally described in below sections.

5.2. Pre-burning and ignition alteration

Pre-burning essentially implies fuel decontamination keeping in mind the end goal to diminish the measure of nitrogen or picking the fuel with low nitrogen content like petroleum gas rather than diesel oil and so forth [13]. It is notable that fuel compose influences the arrangement of NOx through the measure of fuel bound nitrogen (Friebel and Köpsel, 1999). The measure of framed NOx increases for such powers as methanol, ethanol, flammable gas, propane, butane, ultra-low nitrogen fuel oil, fuel oil and coal (Latta et al., 1998). Moreover, substitution of air in the ignition procedure by unadulterated oxygen can likewise essentially diminish the arrangement of NOx. Along these lines, neither warm, nor incite NOx can be shaped (Sterner and Turnheim, 2009). The principle downside of this arrangement is its staggering expense. Because of pre-burning methods, it is simpler to come to the required levels of NOx outflow with the utilization of staying two different ways of NOx emanation control [14].

Burning adjustment can be essentially portrayed as change of operational conditions keeping in mind the end goal to diminish the NOx development. These techniques turned out to be very regular in Poland, since they empowered to satisfy residential norms of NOx outflows (500– 600 mg/m3) (Dora et al., 2009). Be that as it may, they are not adequate to meet new considerably more thorough EU outflow limits.

The principal tests on decreasing NOx outflow by methods for ignition alteration were performed in the late 1950s (Muzio and Quartucy, 1997). In 1959 the impact of O2 level on nitrogen oxides discharge and fuel write was surveyed in Southern California Edison's El Segundo Generating Station (Muzio and Quartucy, 1997). It is notable that principle factors impacting the arrangement of nitrogen oxides in ignition forms are burning temperature (the higher the temperature the higher the NOx development), extent between the measure of air and fuel, blending level of air, fuel and cremation items appropriation. Henceforth, the principle focus of ignition alteration systems is to make oxygen lacking stoichiometric conditions, lessen fire temperature or to fluctuate the living arrangement time inside various parts of the ignition zone (Gomez-Garcia et al., 2005; Javed et al., 2007). This can be accomplished through the utilization of different innovations introduced in Table 3. To deal with the NOx discharge issue low abundance air (LEA) is utilized [15] [16]. This technique can be clarified as constraining the abundance wind current under 2% and has been demonstrated to unequivocally bring down the NOx content in debilitate gases (Environmental Protection Agency, 1999). A definitive level of abundance air is restricted by smoke and CO emanation in the stack (Javed et al., 2007).

Table 4: The Comparison Of Combustion Modification Techniques.

Technique	Description	Advantages	Disadvantages
Low Excess Air (LEA)	Reduces oxygen availability	Easy modification	Low NO_x reduction
		Useful for retrofit of existing power plants	Incomplete burned out (can lead to high levels of CO)
Burners Out of Service (BOOS)	Staged combustion	No capital cost	Generally restricted to gas or oil-fired combustion processes
		Useful for retrofit of existing power plants	Higher air flow for CO
Over Fire Air (OFA)		All fuels	Can lead to high levels of CO High capacity cost
Low NO_x Burner (LNB) air staged	Internal staged combustion	Low operating cost	Moderately high capacity costs
Low NO_x Burner (LNB) flue gas recirculation		All fuels	
Low NO_x Burner (LNB) fuel staged		Useful for retrofit of existing power plants	
Flue Gas Recirculation (FGR)	b30% flue gas recirculated with air, decreasing temperature	High NO_x reduction potential for low nitrogen fuels	Moderately high capital cost and operating cost Affects heat transfer and system pressures High energy consumption Flame instability

5.3. Post-Ignition Techniques

Post-ignition techniques, as the term recommends, are managing nitrogen oxides in deplete gases from burning procedures. They can be utilized as option or supplementary to burning alteration. In this section the wealth of post-ignition strategies was exhibited. They have picked up a considerable measure of consideration, since they can give high NOx discharge diminishment. Be that as it may, these days it is hard to satisfy the stringent emanation necessities utilizing only one system [17].

We arranged a plan Fig. 8 that outlines all the post combustion techniques depicted in this part. As a matter of first importance, two fundamental methodologies can be watched when NOx reduction is viewed as; the first is NOx expulsion from vent gas and the second is NOx decimation. On account of the main approach, NOx is normally evacuated in retention or adsorption forms. The primary downside of these procedures is exchanging the NOx from vent gas to another medium and consequently as a rule creating waste which must be dealt with at that point. The second way to deal with the issue does not posture such a risk since NOx are normally changed to amiable items. Right now, the most usually utilized NOx control strategy is specific synergist decrease (SCR) by smelling salts, which can give up to 85% lessening of NOx (Gomez-Garcia et al., 2005; Barman and Philip, 2006; Brüggemann and Keil, 2008).

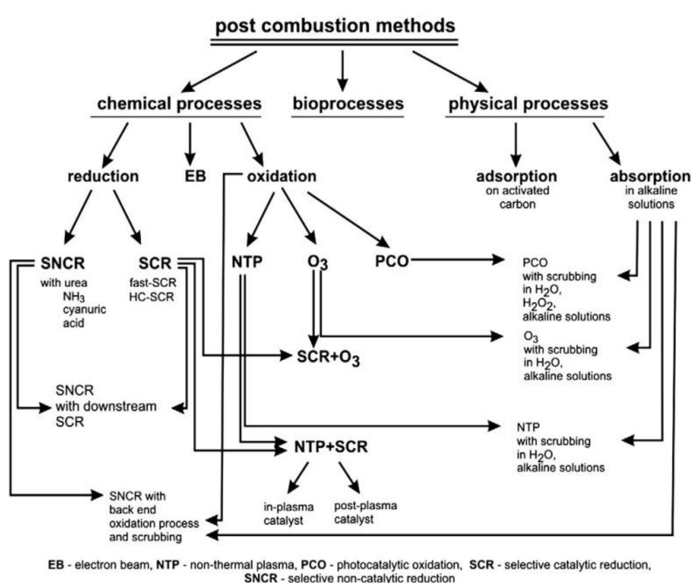

Fig. 8: Schematic presentation of described NO_x abatement post-combustion methods.

The primary business SCR framework started to show up in Japan around 1975 (Muzio and Quartucy, 1997). At that point in 1985, the primary pilot-scale SCR tests were performed on a coal-let go unit in the United States (Muzio and Quartucy, 1997). By and large, SCR is performed with smelling salts within the sight of oxygen [18]. The stoichiometry of this response is:
The response is advanced by an impetus which empowers the response to continue at low temperatures. There are numerous kinds of impetuses utilized as a part of SCR and numerous new ones are being created. Essentially three principle gatherings of impetuses can be recognized [19]:

- Supported honorable metal impetuses, e.g. Pt/Al2O3
- Base metal oxide impetuses, e.g. those containing vanadium
- Metal particle traded zeolites– crystalline silicate, comprising of frequently happening interior pores of sub-atomic measurements and system of connected pens and channels, e.g. Cu-ZSM-5 (GomezGarcia et al., 2005; Elzey et al., 2008).

6. Conclusion

This paper uses patent data from the US, Japan, and Germany to study international technology transfer of pollution control technologies. Inventors respond to domestic regulatory pressures, but not foreign regulatory pressures. There is little increase in foreign patents in either the US or Germany in response to increased domestic emissions standards for NOX or SO2. There are, however, increases in patents from foreigners when regulations in the respective home countries increase.
Finally, it is useful to consider the generalizability of these results, particularly to developing countries. We would expect there to be greater differences in technological sophistication between developing and developed countries than between the US, Japan, and Germany. This has two conflicting implications for applying these results to technology transfers to developing countries.

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