Abas *et al. Environ Syst Res* (2019) 8:10
https://doi.org/10.1186/s40068-019-0138-0

Environmental Systems Research

RESEARCH Open Access

Cooperative control of regional transboundary air pollutants

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Abstract

Background: After food and water, clean air is essential for continuity of life on the planet. Complex trans-boundary air pollution problem is often linked to sustenance and eutrophication. Air pollution problem has no universal conventions like Montreal and Kyoto protocols in case of refrigerants, except regional cooperative solutions. Polluter-pays principle is typically restricted to the source country. Under article 16, International Environment Law mentions the polluter-pay principle without any legitimate power to mitigate the transboundary air pollution risks. Mongolia, Botswana, and Pakistan are ranked as the most polluted countries, although their accumulative emissions are lesser than any of the coal power producing countries.

Results: China, South Africa, and India produce 68–79% of their electricity using coal-fired power plants, emitting harmful pollutants into the common air. Regional winds drive upwind smog into their adjacent downwind countries like Pakistan. This paper compares the published transboundary air pollutant flows data of the most polluted countries (Mongolia, Botswana, Pakistan) with the cleanest ones (Estonia, Mauritius, Australia).

Conclusions: Air pollution externality problem can only be solved either by regional cooperation or global environment law which yet does not exist. Drawing an analogy from water contamination laws, this work proposes an extension of the polluter-pays principle to transboundary air pollutants to compensate the public losses. We should collectively go for the international environmental law as we cannot divide air like land. Industrialization near the border may be banned to avoid air pollutant migrations to neighbors.

Keywords: Polluter-pays principle, Air pollution, Trans-frontier pollution, Aerosols

Background

Ecosphere consists of interrelationships of living organisms with their environment and their interactions are often controlled by abiotic factors such as light, heat, chill, oxygen, soil, and space. Biosphere consists of producers (green plants), consumers (herbivores, carnivores, and omnivores) and destruents (algae and fungi). Nothing is wasted in nature, as an output of one species is the input for the other and vice versa. Natural ecology depends on symbiosis (algae and fungi), parasitism (lice and ticks), predator–prey (lion-goat), competition (vultures and jackals), cooperation (herbivore herds), host–guest (bees and flowers) and neutralism (omnivores) relationship among uncountable living organisms. Living organisms continue disappearing and appearing in nature. Dinosaurs disappeared millions of years ago, and new invasive animals (neozoes) and plants (neophytes) appeared in Europe about 500 years ago. When an animal group becomes extinct, new diverse breed are gradually developed. Earth's spheres consist of the atmosphere (100% air), hydrosphere (71% water), lithosphere (100 km depth) and ecosphere or biosphere (life supporting regions) (Voigt 2007). The most alarming of all human assaults upon the environment is the addition of hazardous pollutants to the air, earth, rivers and finally sea water. Air pollution may be defined as any form of contamination of the atmosphere which disturbs the natural composition and chemistry of the air. Air pollution is irrecoverable after its inception due to its long life. It is easy to stop polluting the natural environment by cooperative regional control (or zero emission

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production policy) rather than removing pollutants from oceans to atmosphere. The continuous pollution of the earth, if unchecked, will eventually damage the quality of life on this planet (Irfan et al. 2018). Air is mankind's common asset that must be protected by not polluting it. Polluting air by burning wheat left over in April–May is a traditional practice in Asian countries. Left-over wheat burning in Pakistan is shown in Fig. 1.

Environments focus their attention on the air pollutants and water contaminants as they keep moving across the globe. Air pollutants include hydrocarbons (HCs), carbon monoxide (CO), sulfur dioxides (SOx), nitrogen oxides (NOx), particulate matter, aerosols, and trace metals, etc. (Murphy 2005) (Abas et al. 2018a, b). Naturally, carbon monoxide is produced by volcanic eruptions, natural gas emissions and incomplete oxidation of methane in the atmosphere. Carbon dioxide is produced by vehicles, boilers, and furnaces in industries under the conditions of complete combustion of carbon (Abas and Khan 2016). Nitrogen oxides are produced naturally by bacterial vegetation and artificially by combustion of coal, oil, and gas. Oxides of sulfur are usually produced by volcanic eruptions (67%) and oxidation of sulfur-containing organic compounds but artificially by combustion of coal, furnace/diesel oil and other fossil fuels in thermal power plants, fire kilns, and petrochemical industries (Abas et al. 2015). Silicon dioxide is produced during stone cutting, pottery, glass and cement manufacturing. Shrubs and trees give off most of the hydrocarbon foliage naturally. Biodegradation of plants and decomposition of animals produces many pollutants. Flowers and microbes spread pollen grains and fungal spores, bacteria, and viruses causing allergy and infection. Human activities like the burning of rice, wheat, and cotton straw pollute the air. Polluting air by burning wheat left over in April–May is a traditional practice in Asian countries. In Pakistan, burning of straw stubble has recently been banned by Punjab Govt in view of rising pollution problem. Left-over wheat burning in Pakistan is shown in Fig. 1.

Fig. 1 **a** Wheat crop being harvested. **b** Wheat crop residue burning. **c** Wheat field scene after burning

Combustion of fossil fuels may produce unburned carbon and hydrocarbons due to inefficient oxidation process. The lead compounds are produced by exhausting fumes from combustion of leaded petrol or oil in internal combustion engines of the vehicles. Dangerous lead compounds present in the airs of China and India reach in Pakistan through downwind. Chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs) and hydro fluorocarbons (HFCs) are used in aerosol sprays, foams, deodorants, air conditioners, refrigerators and heatpump machines (Saleem et al. 2015; Abas 2017). Carbon dioxide, methane, CFCs, nitrogen oxides and others constitute 49, 18, 14, 6 and 13% of overall green gases emissions, respectively. Sources of water pollution include livestock waste, oil spillage, detergents, pesticides, industrial waste effluents and leather tanneries. Domestic solid wastes consist of papers, vegetables, plastics, woods, glass, rubber, leather, textiles, metals and food residues. Solid waste management scientists suggest dumping of debris, explosive, garbage, radioactive and biochemical waste into the seas so as to utilize the larger part of Earth (71%). This dumping of waste may become problematic because of constant traversing of oceanic waters. Buckminster Fuller said, "Pollution is nothing but the resources we are not harvesting. We allow them to disperse because we have been ignorant of their value". CO_2 to CH_4 and waste to energy conversion technologies are the research areas which need to be explored (Abas et al. 2018a, b; Abas et al. 2017; Abas et al. 2017; Abas et al. 2018; Khan et al. 2018). Authors invented a novel solar water heating system employing natural CO_2 as mediating fluid working on principal of natural gravity (Thermosiphon). The proposed system can effectively utilize the green gas (CO_2) and can work even in subzero temperature areas where low solar insolation, chilly winds and overcast days are the key hindrances to harness the solar energy (US 2017/0336101 A1, 2019).

Thermoelectric incinerators seem a better solution for power crisis-hit countries to dispose of municipal waste in exchange for watts. Natural events occur occasionally, but continuous pumping of coal power plants smog into the atmosphere needs to be dealt under polluter-pays principle (Abas et al. 2015).

Smog is a type of air pollutant which is formed by smoke and fog. Smog is produced by burning wood, coal, and oil for energy generation for domestic and commercial use. The sources of smog are traffic smoke, dust, and industrial emissions. Building emulsion paints also emit vapors that result in an increased severity of smog in residential areas. Smog and haze cause solar light dimming but accelerate glacier melting rates through heat absorption by black carbon particles stuck in ice (Himalayan Glaciers: Climate Change, Water Resources and Water Security 2013); (Himalayan Glaciers 2012). Haze and smog often cause a problem for Chinese Authorities to suspend the flights due to limited visibility. Volcanic eruptions in Iceland in 2011 and Indonesian Sumatra Forest Fires in 1997 caused environmental chaos in Asia especially for Singapore and Malaysia as shown in Fig. 2 (Himalayan Glaciers 2012).

Air quality standards recommend reducing current annual repairable suspended particular matters PM_{10} (70 μg/m^3) and $PM_{2.5}$ (35 μg/m^3) to standard 20 μg/m^3 (PM_{10}) and 10 μg/m^3 ($PM_{2.5}$) levels. The current daily pollutant levels of PM_{10} (150 μg/m^3) and $PM_{2.5}$ (75 μg/m^3) should be reduced down to required standards 50 μg/m^3 (PM_{10}) and 25 μg/m^3 ($PM_{2.5}$) levels. Unfortunately, India and China are running a race against the clock, affecting themselves as well as their neighbors. Atmospheric brown clouds (ABC) phenomenon kills thousands of people every year in China and India. Deaths are caused by indoor biomass and coal smoke, but outdoor smog is also responsible for at least 120,000 persons per year in India (Greenpeace, 2013) and 1.2 million persons in China (Wong 2013). WHO has estimated annual death rate of 1619,000 young children from respiratory diseases in developing countries (Brunekreef 2010). Like cigarette brings harm to the active smoker first, then to passive smokers, air pollution is causing damage to the adjoining areas. Air pollution is the fifth cause of death in Indian Territory which seems to be equally valid for China too (Chauhan 2013). Air pollution from coal fired power plants in India and China affects neighbors as well as their own citizens. There is an urgent need for innovative transboundary international environment law to hold back the coal burning nations so that human health and aquatic life can be prevented from further deterioration on local and global levels. Concerned neighbors may resolve transboundary air pollution issues cooperatively and harmoniously.

Materials and methods

In West, air pollution was recognized long time ago (Berge et al. 1999); (Hov 1984), but it emerged in Asia during the 1990s after rapid economic growth of China and India. NO_2 emissions in Europe and America remained about 25 million tons per year from 1970 to 1995 while increasing in Asia, from 10 to 27 million tons per year during 1975–1995 (Alles 2013). China and India

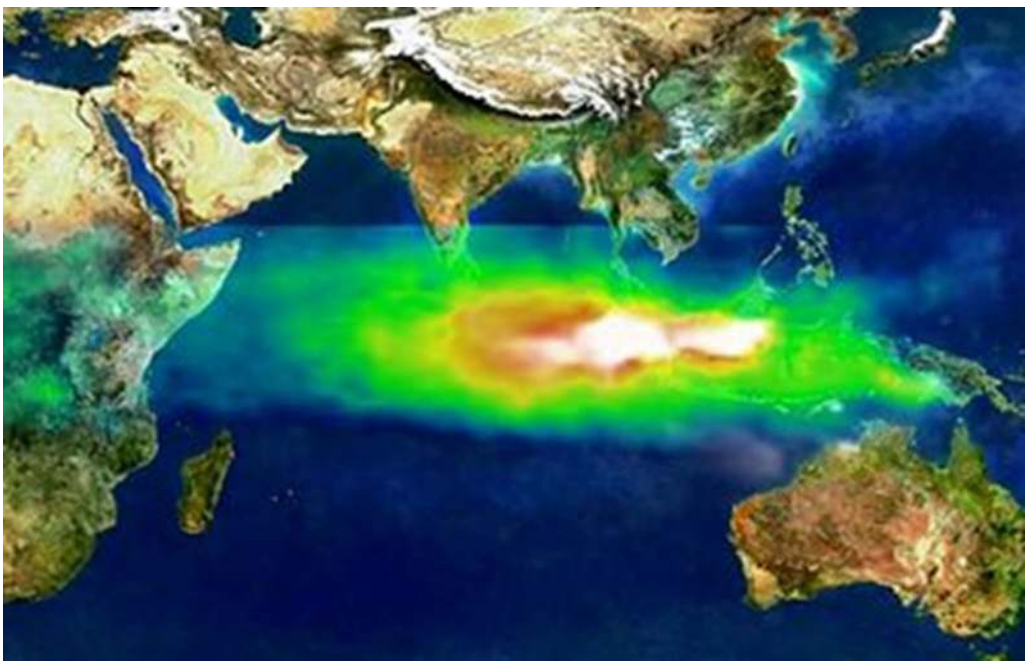

Fig. 2 Smog flow from Sumatra to Malaysia in 1997

consume huge amounts of oil, gas, and coal for transportation and electricity generation. Natural winds and waters mediate transfer of pollutants from upper industrialized states to neighboring lower riparian countries. Trans-frontier pollutants from industrialized nations through natural winds may affect the contiguous underdeveloped states in terms of extra health expenses and loss of crops productivity because hazardous pollutants in air may cause deforestation. Transboundary hazardous pollutants are transported by dry smoggier winds as well as rains showering sulfuric and nitric acids. International law, as well as common sense principle, requires sovereign states to be responsible for transnational air pollution, originating from their territory (Okowa 2000). Many countries are a secondary victim of upwind pollution sources but they hesitate to discuss the matter at the diplomatic level. Transboundary air pollution problems do exist between China, Japan and Hong Kong (Lam et al. 2005), Canada, America, and Mexico, Africa, Europe and Finland (Hov 1984), Indonesia, Singapore and Malaysia, India, Pakistan, South Africa and Botswana. Mongolia, world's most polluted country is sandwiched between industrialized Russia and China, where easterly and westerly winds hurl smog from Russia and China. Sources of air pollution for a country often exist in upwind countries. Western countries first noticed long-range transport of air pollutants in the middle of the twentieth century. The first Convention on Long-Term Transboundary Air Pollution (CLRTAP) was signed per se at the end of the 1970s (CLRTAP 1998), which led to the systematic assessment of economic, social and environmental impacts of transnational pollution sources.

Many countries have signed agreements to point out the transboundary long-range air pollution sources in the world. Malaysia, Indonesia, and Singapore have signed the Asian Agreement on Transboundary Haze Pollution; Japan started air pollution measuring earth net program (EANET) in East Asia in 1992 and Korea started long-range transboundary air pollution program (LTP) in Northeast Asia in 1995. US-Canada-Acid Rain Agreement in 1991 deals with reduction of pollutants such as a sulfur dioxide in Eastern Canada and Northern United States regions (Candel-Sánchez 2006). Indonesian forest fires hurled haze all over Asian region in 1997 (Siddiqui and Quah 2004). Political differences, competitions, and hostilities impede control of unilateral transboundary air pollution. Sovereign nations cannot impose ecotax under polluter pays principle (Chambers and Jensen 2002). When air pollution is linked to eutrophication then extending environmental boundaries (also liabilities) under polluter pay principle is the ultimate cost effecting option to control transboundary air pollution (Tuinstra et al. 2006). China has proposed a transboundary water-pollution tax system model, but this law is governed within their own country (Zhao et al. 2012). A CLRTAP type agreement was signed by SAARC countries under Malé Declaration in Maldives under cooperative environment program (Declaration 1998). A primary focus of the Male Declaration is to monitor dry and wet pollutions, but data also helps to understand local and across the border pollution sources. SARC countries including Iran, monitor respirable suspended particulate matter (PM_{10}), total suspended particulate matter (TSPM), SO_2 and NO_2 under dry and wet deposition conditions. Male Declaration under SACEP established monitoring stations in Kulna (Bangladesh), Gelephu (Bhutan), Hanimaadhoo (Maldives), Rampur (Nepal), Port Canning (India), Dutuwewa (Sri Lanka), Bahawalnagar (Pakistan), and Chamsari (Iran). Measured levels of highest O_3, SO_2 and NO_2 ($\mu g/m^3$) in concerned countries are shown in Fig. 3 (Larsen et al. 2009).

Spatial measurements show the high radiative forcing potential concentrations of CO_2, CH_4, N_2O and halocarbons are higher in the subcontinent but these long-living green gases have not been included in the air pollution monitoring program. Smog is a dusty killer fog that smothers sunlight across Asia (Pasternack 2007). Black fog, containing soot particulates and poisonous sulfur dioxide, is produced during coal burning processes which can be separated with electrostatic precipitators. Photochemical smog (summer smog) is caused by the reaction of sunlight with Nitrogen oxides and volatile organic compounds in the atmosphere, leading to airborne particles and ground-level ozone (Brankov et al. 2003). Winter smog is caused when water droplets are trapped between

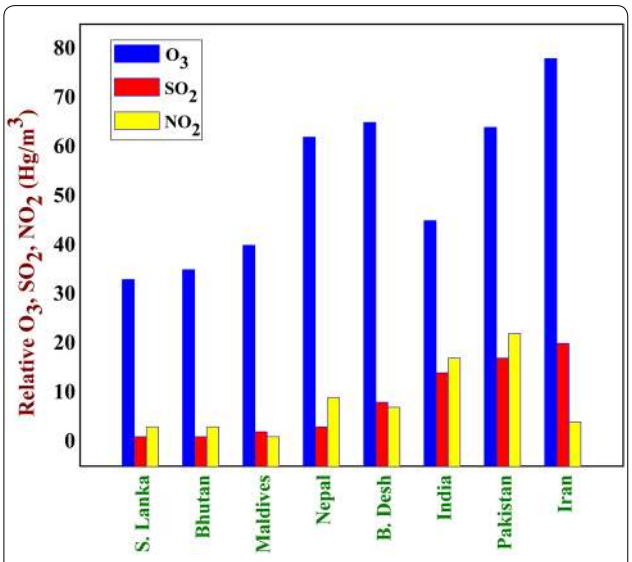

Fig. 3 Relative pollutions in SARC countries

ground and upper-level air layers. Cold air cannot escape, therefore, forms cloudy smog above ground level. Winter smog is thicker than summer smog. Use of excessive pesticides in Indian and Pakistani Punjab also contributes to higher NO_2 concentrations in the air (Syed et al. 2013). Use of pesticide increases air pollution, threatening natural ecosystems. India produces 85,000 metric tons of 145 types of pesticides. Indian farmers use 0.5 kg/ha pesticides so 51% of food commodities are likely to be contaminated (Devi and Raha 2013). Maximum limit of sulfur in high-speed diesel was 1.0% which has been reduced to 0.05%. Experts and officials believe that transboundary effects are multiplying overall air pollution in Pakistan (Bashir 2012). Hudiara drain case study has shown the passage of transboundary pollutants through water from India to Pakistan (Khan et al. 2003). Mean dissolved oxygen was measured to be below 1 mg/L and mean biochemical oxygen demand (BOD) and chemical oxygen demand (COD) exceeded our standard industrial effluent limits. Air and water pollution abatement can be improved by cooperative monitoring and control strategies. Coal-fired power plants and diesel-fueled transport are major sources of air pollution. Pakistan, one of the top climate change hit country, has announced her climate policy to cope with local and transboundary pollution sources. Prime Minister Imran Khan has grown 1 billion trees in KPK and announced to plant ten billion trees in next 5 years to combate climate change and air pollution. Pakistan spends a significant percentage of national GDP on air pollution-related health issues but cannot do much as the sources of air pollutants are located in upwind India.

Coal-fired power plants are key players for injecting smog in the atmosphere. PM_{10} pollution levels in Pakistan, Bangladesh, Nepal, Myanmar, Sri Lanka and Bhutan, are 198, 120, 106, 96, 77 and 18 $\mu g/m^3$, respectively which do not produce any electricity using coal power plants. India with 109 and China with 98 $\mu g/m^3$ PM_{10} are the biggest regional coal-based power producers which are not even listed in top ten PM_{10} polluted countries despite the fact that pollution levels in some of their industrial cities vary from 500 to 900 $\mu g/m^3$. This means that the way we calculate pollution is not satisfactory because it punishes pollutees, not the polluters. Industrialized nations accuse Afghans, and Africans who rely on solar panels, not coal-fired power plants. Pakistan, Nepal, Myanmar, and Bhutan meet 50 to 90% of their power demand by hydroelectricity, yet blamed to be polluters. Mongolia, Botswana, and Pakistan are ranked as the most polluted countries, but they are pollutees, not polluters. Pakistan spends annually Rs. 1 billion to clear pollution mess created by neighbors (Iqbal 2013). Independent experts hold the G-20 countries owe to pay 20 Afghan-African countries $2.2 trillion to clean up the smog mess they have created for them using fossil fuels (Ransel 2011). Three billion the poor, 3.5 billion middle class and 0.5 billion rich produce 7, 43 and 50% of pollution, respectively, on planet but ingeniously point out the poorest people to be responsible for pollution. Mongolia, Botswana and Pakistan are also victims of G-20 countries for being their neighbors. As per literature (TechAlive 2014), average global summer winds patterns transporting transboundary pollutants are shown in Fig. 4.

Global average for PM_{10} national air pollutions and local toxic lead concentrations are 71 and 500 $\mu g/m^3$, however, they are 198 at national and 4400 at metropolitan (Lahore) scales (von Schneidemesser et al. 2010). WHO's safe limit on PM_{10} toxic metals is 2; whereas Pakistan's national average was 340 in 2010. Rising power demand for growing Indian economy is injecting pollutions in atmosphere which sooner or later flows down to Pakistan as shown in Fig. 5 (Himalayan Glaciers 2012).

Tradewinds transfer the Chinese, South African, and Indian coal plants' smog down to Mongolia, Botswana, and Pakistan. Chinese smog goes to Mongolia to Iran and South African smog to Botswana, Namibia, and Angola. Mongolia, Botswana and Pakistan are accused of producing 97.1, 97.2 and 0.4% of their electricity from coal plants. Pakistan's 0.4% is much much lower than 97% of Mongolia and Botswana. Botswana had one 60 MW coal-fired plant that was shut down long ago (Abas et al. 2017a, b).

Pakistan earlier had no considerable number of coal power plants, except a small unit in western part near the sea, and uses compressed natural gas (CNG) for transportation. Government has in built two coal power plants each 1250 MW in 2017. Earlier government had plan of multiple coal power plants, but new government rejected coal power power policy. CNG, LPG, and petrol are clean fuels as compared to diesel and furnace oil. High carbon atoms fuels utilize oxygen and inject smog into the atmosphere. CNG and LPG are more environment-friendly than any other fossil fuel (Abas et al. 2015a, b). Coal, oil, and gas emissions are 1000–1050 g, 778–790 g and 443–469 g of CO_2 per kWh, respectively. This level of CO_2 emission for coal can be reduced to 98–398 g, much less than gas, by deploying carbon capture and sequestration technologies that solve the pollution problem (Sovacool 2008). Coal is all carbon and every ton of coal depletes 2.6 tons of oxygen in the air. NASA satellite image explaining polluter and pollutee is shown in Fig. 6 (Descloitres 2009) and SARC SO_2 data collected under SACEP (Declaration 1998) program is shown in Fig. 7. East to west flowing trade winds and summer monsoons sweep all the smog from India into Paisktan so the pollution monitors located at Bahawalnagar exhibit higher

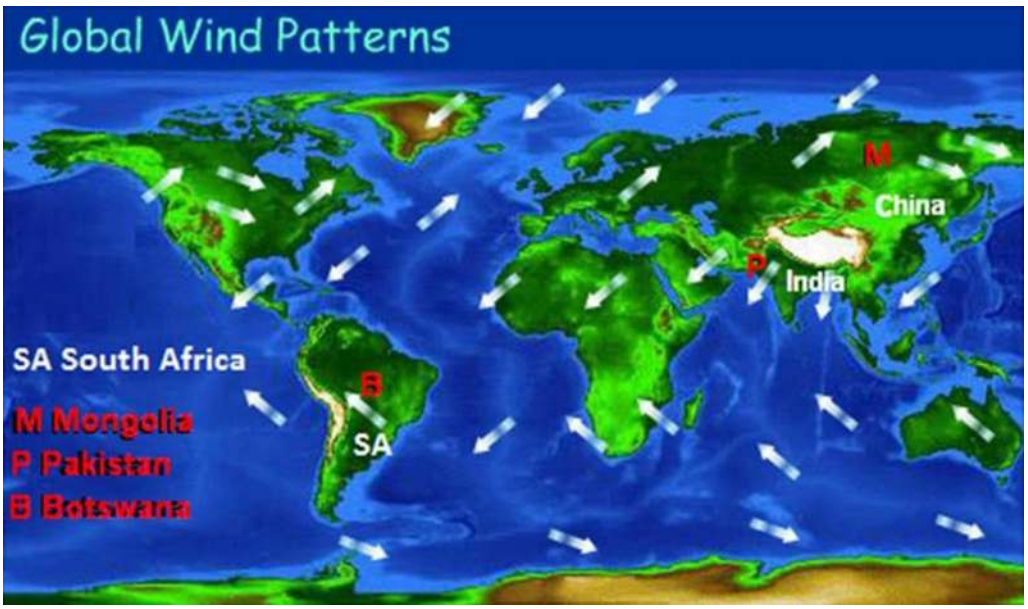

Fig. 4 Asian summer monsoons transporting air pollutants

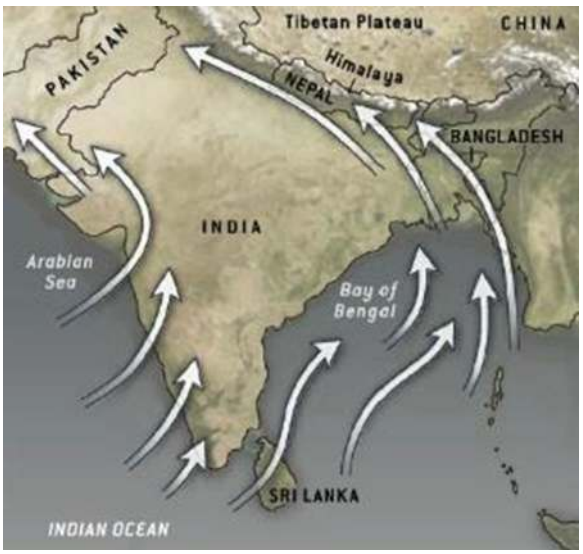

Fig. 5 Summer monsoon flow pattern in Southeast Asia

readings than monitors installed in Rampur and Port Canning. High flux of pollutants comes from India and registered as Pakistan's higher pollution level.

SACEP program does not have provision to measure trans-boundary air pollutants like black carbon particles, CO_2 and CO gases. Under this program, the transboundary sweep smog should be monitored along Himalayan valleys and northeastern Punjab regions which are being affected by upwind pollutants (Syed et al. 2013). Monitoring stations have ingeniously been chosen at southeast Bahawalnagar near the Thar Desert (BN in Fig. 1) in Pakistan and upwind clean Port Canning (PC in Fig. 1) area in India. Pakistan and India must install new monitors on aqua green circles marked location in Fig. 1 to record the actual air pollutions. A standard set of long-range transboundary air pollution monitoring parameters are well reported in the literature (de Leeuw 2002). Impact of coal power plants CO_2 capture and storage on long-range transboundary air pollution is also available to reduce neighbor's grievances if there is will to mitigate air pollutions (Koornneef et al. 2009).

Spatio-temporal monitoring over Pakistan, using moderate resolution imaging spectrometer (MODIS), total ozone mapping spectrometer (TOMS) and multi-angle imaging spectrometer (MISR) satellite data from 1979 to 2008 show rising aerosol concentrations over Pakistan (Alam et al. 2011). Local Indian researchers believe high levels of total ozone concentrations (TOC) in both countries but ingeniously relate it to use of dung and woods (Pal 2010), but NASA satellite image shows live thick clouds of smog continually flowing from India to Pakistan. Indian environmental experts do recognize transboundary air pollution problem considering coal fuel as a source of the myriad problems. The existence of international transboundary law can drive India to capture and store the pollutants being pumped into the air.

Typical aerosol optical depth varies from 0.1 (palest yellow: clear visibility) to 1.0 (reddish brown: hazy conditions). High AOD values may be attributed to dust, sea

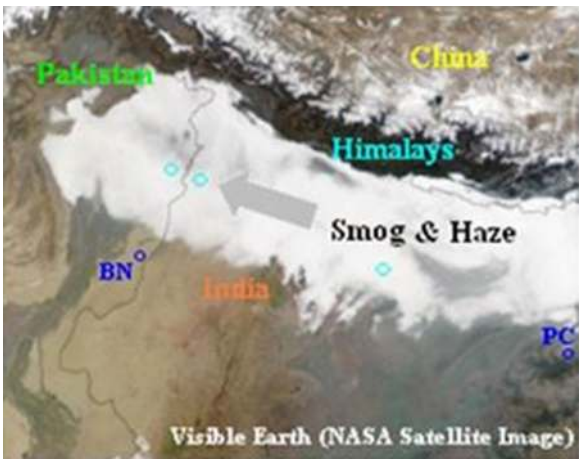

Fig. 6 Flow of smog and haze from India to Pakistan

Fig. 7 Relative SO_2 concentrations in SARC countries

salts and coal power plant smoke in the air. Depending upon location, the AOD causes cooling or heating effect and may support or inhibit cloud formation. Sarkar et al. (2006) carried out testing of AOD over India in 2006 and found AOD to vary from 1.0 to 1.18 in most Indian cities. NASA captured dark images of dense smog clouds in their Figs. 2, 3 moving from North East of India in January to East of Pakistan in June 2005. Sarkar (2006) showed aerosols and smog flow from China into India, augmenting overall air pollution. Pal (2010) carried out air pollution study in India and Sarkar in USA. Both researchers have carried out similar studies, but their findings conclude different results. Summer monsoons flow from the Himalayas through India, Pakistan to Arabian and India Seas, pre-monsoon from the Arabian Sea to Pakistan and India, high monsoon from sea to India and post-monsoon back to the Arabian Sea. Monsoons transport sea salt to India and sweep Indian (as well as Chinese) pollutants into Pakistan. Recent studies (Ramachandran and Kedia 2013) show the relatively higher level of AOD in Karachi due to summer monsoon pollutants as shown in Table 1.

Indian coal plants smog flows to Pakistan in summer through monsoons but spreads around during winter. Indian air pollution problem becomes severe in the winter. Several AOD studies were undertaken in India on winter smog problem. Generally, AOD is about 0.6 at 1 μm over most parts of India which peaks to 0.9 to 1.0 at 0.4 μm in coal power plants areas (Ramachandran et al. 2012). Spatio-temporal variation study in China from period 1980–2008 showed high rising AOD trend of 0.01 per decade from 1980 to 2000 and low rising trend of 0.004 per decade from 2000 to 2008 (Guan et al. 2011). The AOD trend has declined by 15% per decade, but underlying increase tendency continues. AOD over the most affected Chinese cities varies from 1.5 to 1.6 which is recommended to be 0.01 to 0.02. Chinese coal power plants are located at 130°E to 100°E and 50°N to 22°N areas whereas Indian power plants are sparsely located but densely situated in the northeast. Monsoon winds emanating from the Bay of Bengal drive all air pollutions into Pakistan.

Energy crisis has led power outages of 12 to 15 h daily which indicates the crippling situation of local industry in Pakistan. In India, aerosols concentration increases from March to August which lands to ground level in Pakistan due to downwind in winter chill. The respiratory sickness rates increase in India during winter as most of the smog also hangs over the polluters in winter. Adoption of polluter pays principle is not only the demand of Pakistani nationals but also the need of Indian population suffering from their local coal power plants with off-gas purification systems available to solve the air pollution problem.

Table 1 AOD (0.5 μm) Levels over South Asia (Ramachandran and Kedia 2013)

Seasons	Kanpur	Karachi	Gandhi College
Winter	0.88 ± 0.32	0.38 ± 0.18	0.87 ± 0.34
Pre-monsoon	0.66 ± 0.22	0.40 ± 0.12	0.55 ± 0.24
Monsoon	0.65 ± 0.11	0.60 ± 0.31	0.63 ± 0.29
Post-monsoon	0.83 ± 0.31	0.34 ± 0.14	0.69 ± 0.26

Thousands of Indian nationals die every year with the smog-related respiratory diseases without any national compensation schemes. When polluting utilities do not pay to their own citizens then how they will compensate to the down affected foreigners? Air pollution externality problem can only be solved either by regional cooperation or global environment law which yet does not exist. Moreover, laws alone cannot work successfully in absence of mass-cooperation. Hence, an awareness campaign can support the cause and teachers (Yasmin et al. 2019), who are agent of change, can accelerate the efforts (Yasmin and Sohail 2018a, b; Yasmin et al. 2017).

Air pollution can efficiently be controlled from the source. Combustion of oil and gas in transport vehicles and coal-fired power plants, cement industries, and fire kilns are significant sources of smog. The fuels can be lead-free to reduce the level of lead in the atmosphere. Advanced burners efficiently lessen the smoke and NO_X emission from the flue gases. Electric vehicles and sunlight power cars can mitigate photochemical smog. Europe has effectively solved smog, and pollutant flow problem by regional control policies and this seems to be a guideline for Pakistan, India, and China. The polluter-pays principle is the ultimate way out. The polluting industrial gases should be processed through filters and cyclone collectors, scrubbers and precipitators to remove particulate matter. Toxic gases may be detoxified before releasing them into the atmosphere. Pollutants may be converted to less harmful gases by combustion, detoxified by passing through liquid absorbers, trapped in solid adsorbents or controlling emission of particulate matter by gravity, filter bags, Jet pulse filters, wet scrubbers and electrostatic precipitators. Research focusing on transboundary air pollution and converting poisonous effluents to useful green fuels has become a need of the day. Practical efforts may include use of smokeless fuels in hearths, maintaining vehicle engines, plant trees along roads, and use renewable solar energy. It is essential to educate people and create public awareness for more effective control and prevention of air pollution, but the ultimate solution is the implementation of trans-boundary polluter pays principle.

Results

Air pollution is a justice snag beyond jurisdictional boundaries (Nordenstam et al. 1998). If there was ever need of global environmental Law, then it is now. Experts emphasize regional cooperation for effective abatement and control of trans-boundary air pollution problems in East and West (Min 2001). Internal forums and trade policies can help to enhance collaboration between hostile countries. Transboundary air pollution has necessitated international cooperation rather than individual efforts. Transboundary air pollution issue can perhaps be better resolved by consensus on common good between stakeholders. It can be promoted by motivation and adaptive policies (Andrew et al. 2012). A few countries have their own Clean Air Acts and Environment Laws which are not being adhered to at least in SAARC countries. Upwind polluted countries not only damage the health of their citizens but also cause environmental problems for their downwind neighbors. UN-ECE protocols, supply clear guidance on acute and chronic health effects of trans-boundary air pollutions (Krewitt et al. 1998). Air pollution has a negative impact on life satisfaction, high death rates and low soil productivity leading to life and economic losses (Luechinger 2010). UNO, IPCC, and WHO agreed to Montreal and Kyoto Protocols to ban ozone-depleting gases and global warming refrigerants but took no practical steps against air polluters (Spellman 2008) (Abas et al. 2015a, b). The air pollution ranking authorities can advocate international environment law to penalize the air polluting countries. Helsinki Convention takes care of trans-boundary watercourses and lakes which can be extended to the transnational atmosphere with minor augmentations for air pollution. Polluter-pays principle is mentioned under article 15 of the Rio Declaration on environment and development as an international guideline, but polluter pays-principle in practice is dealt as pollutee pays principle, and strangely pollutee is ranked as the most polluted country. It is the right time to create an international environmental law focusing on trans-boundary air pollution. Japan and China went to saber-rattling over air pollution in the recent past. Oil depletion is likely to ratchet up coal and biomass consumption by 2050 when Himalayan glaciers retreat would be accomplished. Oceans absorb CO_2 from the air and become acidic to damage marine life (Khan et al. 2017). The global community is heading to stone-age style wars with deadly weapons over natural reserves. Sanctions against polluters are feeble and out of date, and, in any case, are rarely invoked.

Industrialized polluters vacillate over net emission based ecotax policies to compensate affected neighboring nations. Polluter pays principle is being reversed by developed nations to blame the affected pollutees (Nash 2000). Air, water or land pollution is a nuisance which has been developed by stronger countries, and weaker neighbors are at receiving end. Pollution affects millions of innocent people who genuinely may be treated equivalent to a weapon of mass destruction. Combusted fossil fuels remnants, depleted uranium, and biochemical waste cause serious problems which world faces today. Transboundary air pollution conflicts demand legislation of international environmental law upholding the polluter pays principle (Gaines 1991). The polluter-pays principle

is enacted to make the party responsible for producing pollution for paying for the damage done to the natural environment. Clean Air Acts have been enacted in many countries at the national level to reduce airborne contaminants, smog and air pollution which need to be extended to international standards. India and China have their local environmental laws and clean air acts, but their air pollutants hardly meet their own environmental pollution guidelines. We have trans-boundary water contamination laws but no air pollution control restraints, though we use water hardly thrice a day but breathe air every instant. Upwind high population countries emit 2.5 billion kgCO_2 that cause regional greenhouse effect in downwind states (Abas and Khan 2014). Transboundary pollution problem like water may be solved by the addition of "air" to the existing "water" Helsinki Convention.

Discussions

The ranking system is based on many misleading criteria like population and human carbon dioxide exhaling, ignoring industrialization, coal power plants, and daily oil consumptions. The people of USA is just 5% of global population, but their consumption is 20% of global oil. An ordinary person in the most developed country emits more carbon dioxide in common air due to his high living standards than 100 people in Botswana. Industrialized nations create 70 to 80% of total air pollution themselves but accuse wombs of third world women. The tsunami destroyed nuclear power plants in Japan, but its effects have been noted on American borders. Japan is under pressure on one hand for hurling radioactive waste and on the other hand for sending aerial pollution to China as China is sending to downstream Mongolia (Kohan 2011). China and India both affect their neighbors by coal fired power plants, wood fires and stubble fires but they have affected themselves too. Over 3 km thick ABC layer is stretched from China to India over Pakistan to Arabian Peninsula. It has dimmed 10–25% sunlight, blinding eyes of all Asians (Descloitres 2009). According to World Bank report, the air pollution in China has killed 760,000 citizens. Smog kills over 340,000 Chinese and Indians every year due to smog respiratory diseases (Pasternack 2007), which is the old figure, now the death rates might be even higher. India enjoys coal-fired power plants and diesel driven economy which are the worst sources of pollution. Widespread use of coal and diesel in India is smoggier than petrol (Hindus, 2004). The pieces of lands or seas we use for dumping radioactive and biochemical wastes are used up forever. Coal, oil, gas, wood and nuclear power plants worsen air and water quality, latter may be slightly lesser fatal than the former. The carbon-free energy system is the sustainable solution that we should adopt instead of waiting for oil depletion in the 2060s, gas in 2070s, uranium in 2090s and coal in 2150s when the oceans would have become acidic and air poisonous (Bentley 2002). Pakistan does not produce coal power yet it is stormed by the smog of neighbors. The founding leaders wanted both the countries (Pakistan and the India) to live in harmony like USA and Canada, but subsequent events led to distrust between both nations. Pakistan being downwind state depends upon upwind pollutions. India has a good experience of applying the polluter pays principle within own territory (Luppi et al. 2012), which can be extended across the borders to compensate downwind victims. We have regional examples of multilateral cooperative initiatives like marine basins (Pernetta and Jiang 2013) and the South China Sea (Bewers and Pernetta 2013). South Asian nations are already collaborating on pollution measurement and prevention under Male Declaration (Declaration 1998), which may be extended to incorporate polluter pays principle among the most affected countries. The basic infrastructure exists already, yet an organization structure of body taking care of conclusive implementation is shown in Fig. 8.

As an integral part of Male Declaration, both nations can sit down together or through UNO representatives, they can resolve the coal-fired smog problem that is taking the lives of innocent citizens having no access to medicines and education. Upwind countries produce 68 to 79% coal-fired power and throw the smog and toxic pollutants into the open atmosphere. World community expect from power producers to pay ecotax amount of which be shared with affected counties (Rahman and Edwards 2004). In the energy-hungry modern world, the victims do not know the culprits which may be located far away from the pollutee.

A fewer developed nations are responsible for global water, air, and land pollutions, rest of all are affected parties. It is not green on blue politics the polluters hold power to make rules to redress the grievances of affected pollutee. Surprisingly, the victim is not even allowed to write or speak on privileged media. In view of prevailing paradoxes of the polluters, there is an urgent need of implementing truth emergency on planet Earth. Independent analysts hold the Mongolia, Botswana, and Pakistan among the most affected countries of the air pollutions caused by their neighbors. World community blames Pakistan for equivocating on polluter pays principle, none points out the ingenious neighbor polluter (Luken 2009). Pakistani spent $8.3 million from 2000 to 2007 on treating the water pollutions and cannot afford to pay huge sums on cleansing air pollutions, sent as a gift by neighbors. Countries ranked as relatively less polluted are pumping more air pollutants into the atmosphere than the most polluted countries.

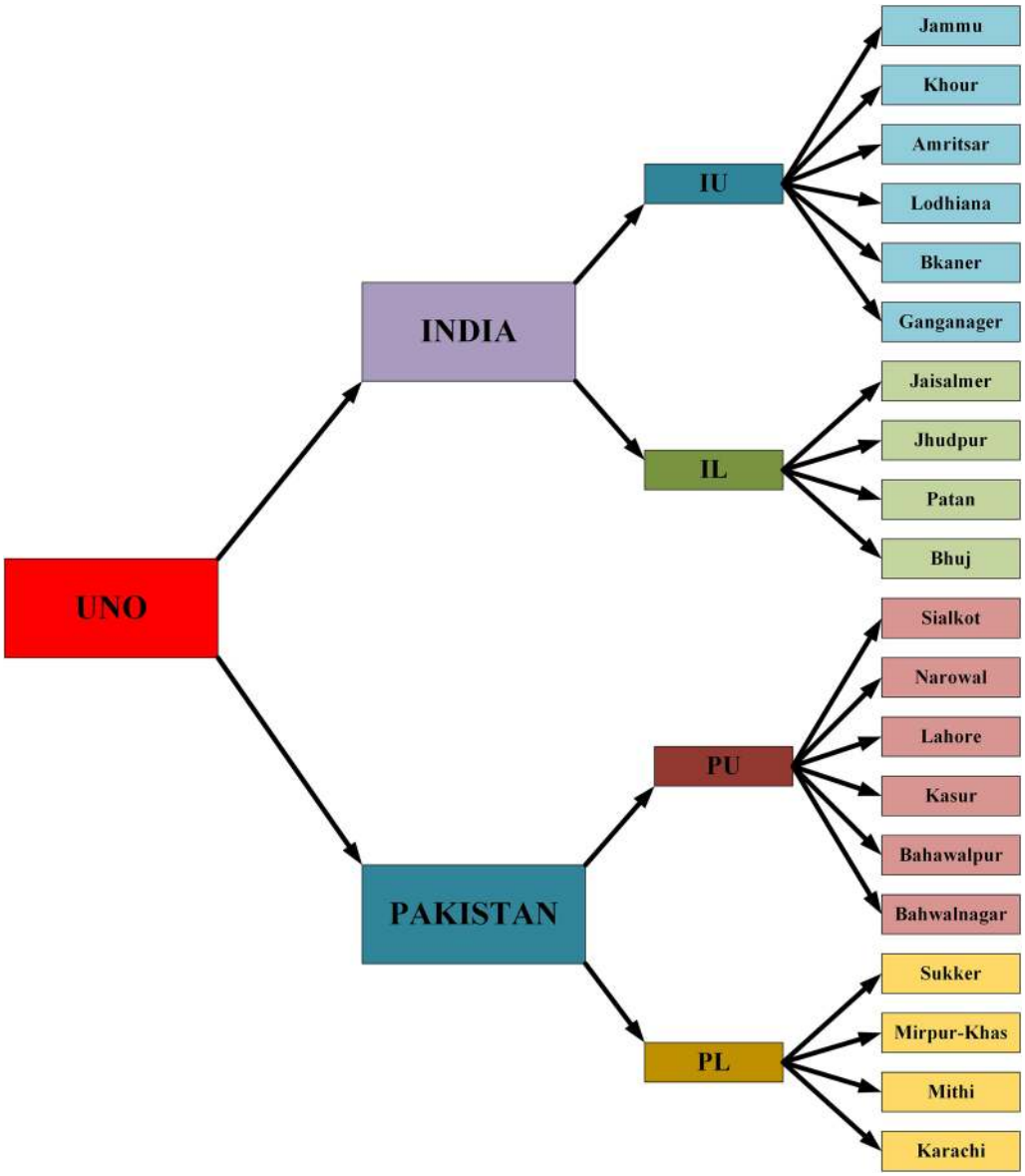

Fig. 8 Proposed organogram of polluter Pay Principle Project (U/L upper/lower)

Carbon dioxide emissions of the most polluted Mongolia, Botswana, and Pakistan, are 0.04, 0.02 and 0.55%, respectively of global emissions. Carbon dioxide emissions of Estonia, Mauritius, and Australia are 0.06, 0.01 and 1.34%, respectively of global emissions. China, South Africa, and India produce 78.3, 93.1 and 70.6% of their electricity using coal power plants but their neighbors are being asphyxiated for the sin which they never committed. Sums of carbon dioxide emissions by the most polluted and the cleanest three countries are 0.61 and 1.41, respectively. The cleanest countries release more than twice carbon dioxide into the atmosphere than the most polluted countries (Abas and Khan 2014). This clearly reflects the fact that population and carbon dioxide emissions have nothing to do with their air pollution ranking. World leaders pointlessly focus on population and carbon dioxide which are not the real causes of crises, (water, and air pollutions). Population threat stands on pillars of subsistence, resources, and scarcity which might take us back to stone-age views. Carbon dioxide is a green gas, not air pollutant, so its link to population is a misleading idea. Per capita index is simply total emissions divided by total population. If population of any country decreases then her per capita emission increases—a senseless

index. Population densities of Estonia, Mauritius, and Australia are 30, 617 and 3 persons/km^2, respectively but they are ranked as the cleanest countries whereas population densities of Mongolia, Botswana and Pakistan are 1.7, 3 and 227 persons/km^2, respectively but they are portrayed as the polluted countries.

Waste and air pollution are driven by population and economic growth (Zia and Devadas 2008), which demands more and more energy derived from coal, oil, and gas. Fossil fuels fired power plants—primarily coal-fired—are the real causes of air pollution all around. Per capita, energy consumptions in China and India are 397 and 85 watts per person whereas numbers for Mongolia and Pakistan are 140 and 47, respectively. Nobody has control over natural winds, but everybody can at least treat its smokes, else industrialized nations can pay the price of environmental and health hazards to affected parties. USA, EU, and Russia in West and China, India and Japan in East produce 18.27, 13.98, 5.78 and 23.50, 5.83 and 4.04%, respectively of global carbon dioxide emissions. Top six industrialized nations hurl over 71% of 29.89 billion tons of CO_2 emissions annually in their local atmospheres, which are blown away by natural winds to neighboring countries. A dangerous and blind race between China and India to pursue their progress is becoming a source of tremendous loss to common citizens of neighboring countries. Japan and China accuse each other of $PM_{2.5}$ air pollution but genuinely speaking both are culprit polluters affecting each other and neighbors. Winds emanating from the Arabian Sea take a turn from Bay of Bengal pushing Indian smog in Indian Himalayan valleys to Pakistan (Chauhan 2013).

Trade and Monsoon winds push Sino-Indo (Sindo) smog into Pakistan all the way down to Arabian Peninsula. Black carbon in Sindo smog gets deposited on the Hindu Kush, Karakoram (K2), Mount Everest and Himalayan glaciers to absorb sunlight to melt millennial old ice deposits. Nature maintains environmental ecology by accelerating glaciers' melting rate on eastern Himalayan Mountains compared to stable western regions. Sindo smog is likely to wreak water shortages havoc in India due to its coal power policies. Regular trade winds flowing from China to Mongolia, South Africa to Botswana and India to Pakistan sweep the smog clouds from producers to neighbors. Mongolia, Botswana, and Pakistan are projected as polluters, but they are in fact victims of environmental terrorism of their neighbors. Damian regards Indo-Sino smog as an air mageddon against neighboring communities (Damian 2013).

Wherever we dump the waste it will return to the producer through natural winds and water flows. International pollution ranking parameters, in the absence of transboundary environment law, do not judge the real polluters. Nowhere in the world, the race for infinite growth and endless profits is mandated. Humans are not fishes who pollute the water wherein they live. Economic growth is hinged upon energy security and environmental sustainability, so the free market based economic systems can be the linchpin for snowballing pollutions. Economic growth has no limit, but the natural resources are limited. To deal with the waste problem, the world community will collectively have to go for polluter pays principle instead of ingenious institutional excuses. For national air pollution ranking, the parameter such as net individual should be used instead of per capita or km square which are skeptical. Arab countries are referred as oil and gas guzzlers on per head basis without telling the total heads. G-20 owes to pay $ 2.2 trillion to G-20 affected nations as eco-tax and fossil fuels smog tax under polluter pays principle (Alam et al. 2011).

Conclusions

Open coal-fired power plants are the ground zero for smog and air pollution. Power plants and industries are operated in the same biosphere where we live and breathe. Waters and air have no boundaries, so must be governed by the international trans-boundary laws. Polluters are acting as escaping water, and pollutee as fish which are not captured by ranking nets. We have to manage the whole of ecosphere even if we do it for ourselves alone. We hate or love we cannot escape the planet, so we have to do or die together. Land, water and air polluters (not pollutee) are the collective adversaries of humanity. India and China both produce 70 to 80% of their electricity using coal-fired power plants. These upwind coal power plants emit green gases and pollutants which flow to Pakistan through summer monsoons and trade winds. We should collectively go for the international environmental law as we cannot divide air like land. It is late yet in time to move ahead for individual benefits instead of looming collective failure. Similar Environmental laws for air and water pollution control must be applied in all neighboring countries. Air pollution must be monitored along borders to record amount of pollutants and directions of flows on daily basis to compensate each other under polluter pays principle. Industrialization near the border may be banned to avoid air pollutant migrations to neighbors.

Abbreviations

CFC: chlorofluorocarbons; HCFC: hydro chlorofluorocarbons; HFC: hydro fluorocarbons; WHO: World Health Organization; CLRTAP: Convention on Long-Term Transboundary Air Pollution; EANET: Acid Deposition Monitoring Network in East Asia; LTP: Long-Range Trans-Boundary Air Pollution Program; BOD: biochemical oxygen demand; COD: chemical oxygen demand; CNG: compressed natural gas; LPG: liquefied petroleum gas; MODIS: moderate

resolution imaging spectrometer; TOMS: total ozone mapping spectrometer; TOC: total ozone concentrations.

Authors' contributions
NA and NK conceived the idea of paper, contributed to its development and performed study selection, data extraction and analysis. MSS and EK collected data. NA wrote the manuscript. All authors provided editorial feedback. All authors read and approved the final manuscript.

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Acknowledgements
This research was in part supported by a grant from Higher Education Commission of Pakistan under Technology Development Fund (TDF02-86).

Competing interests
The authors declare that they have no competing interests.

Availability of data and supporting materials
Please contact author for data requests.

Consent for publication
Not applicable: This manuscript does not contain any individual person's data in any form.

Ethics approval and consent to participate
Not applicable: This manuscript does not report on or involve the use of any animal or human data or tissue, so this section is not applicable to our submission.

Funding
This research was in part supported by a grant from Higher Education Commission of Pakistan under Technology Development Fund (TDF02-86).

Publisher's Note

Received: 16 November 2018 Accepted: 20 March 2019
Published online: 30 March 2019

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