Air Pollution by Inland Waterways Transportation in India

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Abstract. ***Economy of any country depends on the existence of an efficient transport sector. There exists different modes of transportation such as railways, roadways, inland waterways, coastal shipping and airways. Sea freight is the best choice for international freight shipping because ships are used for transporting 80% of the world's goods by volume. But at the same time, it becomes a great threat to human and ecosystem in the form of carbon emissions. Now-a-days, inland waterways are preferred over roadways and railways for domestic shipping in all the countries. India invests more in the development of inland waterways to have a cost effective cargo shipping. As the number of inland vessels increases, it may lead to the severe impact on environment due to more carbon emissions. Unless steps to reduce carbon emissions from vessels are adopted, it could increase by as much as 20% to 120% by 2050. This study reviews the inland waterways transportation of India and investigates the air pollution from inland vessels.***

Keywords: ***inland vessel; air pollution; carbon emission; transportation; environment***

I. INTRODUCTION

Transportation is the one of the deciding factors of the wealth of a nation. Railways, Roadways, Airways and Waterways are the various modes of transportation. Urban areas and cities in all the countries are well connected with roads and find the limited use of railways and other transport for cargo movement. Due to demographic development, the volume of the transport will continue to grow in terms of number of people movement and the amount of goods transported. Hence it becomes challenging task to manage increasing urban cargo traffic [8]. Waterways are the only effective way of shipping bulk cargo with no traffic congestion. Durajczyk P and Drop N [4] analysed the use of inland waterways for urban logistics and provided the comparison between road and inland transport in terms of costs, carbon dioxide (CO_2) emissions and time. Since ship emission becomes a major source of air pollution in inland water regions, it urgently requires emission inventory. Automatic Identification System (AIS) based emission model is currently used in estimating the ocean-going ship emission inventory. Due to unavailability of AIS data in the inland rivers, fuel consumption method is widely used for inland ship emission inventory. Jiang H. et al. [9] compared test data and model calculated data to evaluate the accuracy of AIS based emission models. Even though shipping is considered to be environment friendly transportation, it exhausts a large number of pollutants such as SO_2, NO_X, PM and CO and HC because of high power engines using heavy oil [11]. Liu H et al. [12] studied about the emission of CO_2 from ships and predicted that the ship emissions in Asia would increase from 7% in 2005 to 16% in 2013.

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Moldanová, J et al [13] provided their perspective on holistic approach to the studies of impact of operational shipping on atmospheric, marine and under-water pollution simultaneously. They used Driver–Pressure–State–Impact–Response (DPSIR) framework to investigate the impact of shipping on the environment in the Baltic Sea region. They stated that the major air pollutants from ship emissions are SOx, NOx and PM. Other then these pollutants, emissions of CO, Volatile Organic Compounds (VOC) and Polyaromatic hydrocarbons (PAH) from ships also contribute to the air pollution. They also discussed the use of LNG instead of diesel fuels to reduce the emissions of air pollutants like NOx, SOx and PM. But the impact of LNG on climate is higher comapred to diesel fuels if unburned methane escapes from ships. Stefan Gossling et al. [16] reviewed global, national, regional and port-level legislative approaches that have been implemented to reduce emissions of CO_2, NOx, SOx and PM. They suggested the IMO to significantly toughen the regulatory policies in the shipping sector to achieve the requirements of low air pollution and zero-carbon emissions. Halil Saraçoğlu et al. [7] estimated exhaust gas emissions from ships in Izmir Port, Turkey by the ship activity-based methodology and proved the ship emissions as major cause of air pollution of Izmir city. Erik Ytreberg et al. [5] made a comprehensive study of impact of ship emissions on marine environment, air quality and human health. They developed a framework to quantify the societal damage costs of shipping due to degradation of human welfare in a Baltic Sea region.

The paper consists of seven sections: Introduction is given in Section 1. Inland Waterways transport is briefed in Section 2. Navigable National Waterways of India is detailed in Section 3. Cargo movement on waterways is elaborated in Section 4. Statistics of various types of inland vessels which are running in different states of India, volume of cargo carried by them and fuel consumption of the vessels are given in Section 5. Air pollution from different vessels especially in inland waterways is discussed in Section 6. Conclusion is given in Section 7.

II. INLAND WATERWAYS TRANSPORT

Inland Waterways Transport (IWT) is the transport of cargo and passengers carried over rivers, canals, backwaters and creeks using inland vessels such as ships, mechanised boats, trawlers, dredgers, ferries and tugs. Inland vessels are used for connecting goods to remote and interior parts of the country where large ocean carriers are unreachable. It is the safest and environment friendly mode of transportation. Moreover, it incurs low maintenance cost since channels are mostly natural and several times lower external costs account for accidents, congestion, noise emission, air pollution and other environmental impacts when compared to road transport [6]. It is the most economic mode of transportation because of low capital cost and fuel efficient.

In order to facilitate inland waterways for transportation, the following components such as Navigational facilities, Transportation facilities, Terminal facilities and Last mile connectivity are to be developed. According to Inland Waterways Authority of India (IWAI), a channel must have 2 m draft available throughout the waterways which can allow a barge with 1.8 m draft to operate. The prescribed widths of waterways are 32 m and 38 m on closed channels and open channels respectively. The channel should be equipped with the following navigational aids such as river notices and navigational charts, navigational marks and night navigation system. Transportation facilities such as inland vessels/barges required to carry the goods and passengers. In addition, vessels are required for dredging and inspection work. Terminals are required at regular intervals with the following facilities such as jetties for berthing of vessels, space for loading and unloading cargo, storage area for cargo and equipments like cranes for handling cargo movement. Last mile connectivity is another major issue in IWT to provide end-to-end movement. Instead of multiple interfaces, there must be an integrated logistics model by which end-to-end shipping can be done easily.

III. NATIONAL WATERWAYS OF INDIA

India has a strong history of shipping since ancient times. India has also wide network of rivers, lakes, canals and backwaters. At present, India has more than 14,500 km of inland waterways with rivers, canals, backwaters, creeks, etc. About 55 million tones of cargo are being moved annually by Inland Water Transport, in a fuel-efficient and environment-friendly mode. IWAI was constituted in October 1986, for the development and regulation of inland waterways for shipping and navigation. The National Transport Policy Committee declared five national waterways: The Sunderbans, The Mahanadi, The Narmada, The Mandovi, Zuari rivers and Cumberjua Canal in Goa and The Tapi. The comparison of 5 National Waterways (NWs) are given in Table 1[6].

As per the National Waterways Act, 2016, 111 have been declared as National Waterways. These waterways pass through various 24 states and 2 union territories with an approximate length of 20275 km. Out of 111 NWs, 13 NWs are operational for shipping and navigation and cargo/passenger vessels. The details of operational NWs [14] are given in Table 2.

The details of National Waterways (NWs) with their total length is shown in Fig. 2. There are numerous challenges in the development of inland waterways such as operating cost, inadequate depth, inadequate air draft, lack of night navigation infrastructure, shortage of facilities for repair and maintenance of inland vessels, lack of funds and environmental impact. In this work, impact of operation of inland vessels on environment is investigated and insisted to implement policies to amend regulations in the IV Act.

The navigable inland waterways in India is shown in Fig. 1.

The various ACTS related to waterways in India are as follows:

1. COASTING VESSELS ACT, 1838
2. MERCHANT SHIPPING ACT, 1958
3. THE INLAND VESSEL ACT, 1917
4. NATIONAL WATERWAYS ACT, 2016
5. THE INLAND VESSEL ACT, 2020
6. THE INLAND VESSEL ACT, 2021 [22]

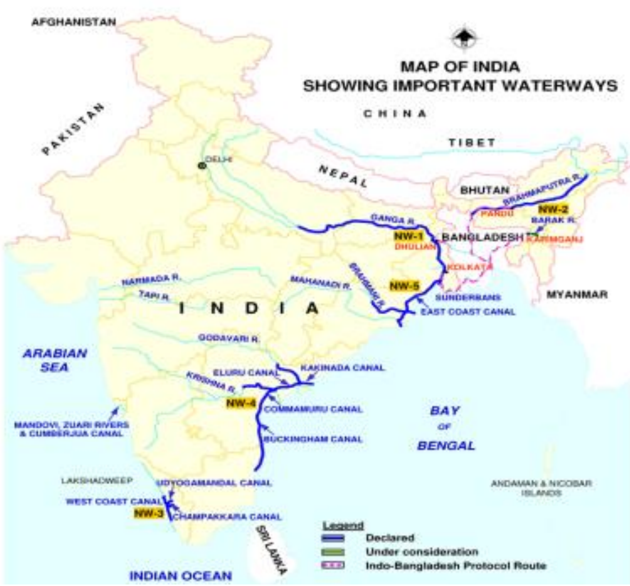

Fig. 1 Navigable inland waterways of India

Fig. 2 NWs with their total length

IV. CARGO MOVEMENT ON MAJOR WATERWAYS

Out of major waterways, it has been observed that three national waterways of Goa, Maharashtra and Gujarat & Sunderbans which carry large amount of cargo traffic on India's inland waterways. The total cargo movement on these three waterways was 685.13 Lakh tonnes in 2019-20 and it reflected the increase of 1.79% in cargo movement as against 673.11 Lakh tonnes in 2018-19. Further, waterways Goa, Maharashtra and Gujarat & Sunderbans accounted for 4.31%, 30.58%, 45.27% and 5.06% respectively of the total

Table 1 Comparison of 5 NWs

	NW 1	NW2	NW3	NW4	NW5
Year of declaration	1986	1988	1993	2008	2008
Rivers & Path	The Ganga - Bhagirathi - Hooghly river system between Haldia (Sagar) & Allahabad	The river Brahmaputra between Bangladesh Border and Sadiya	168-km West Coast canal (Kottapuram Kollam) segment, the 23-km Udyogmandal canal - Kochi Pathalam bridge portion and the 14-km Champakara canal (Kochi Ambalamugal)	Kakinada Puducherry stretch of canals, the Kaluvelly tank Bhadrachalam Rajahmundry stretch of the river Godavari and the WazirabadVijayawada stretch of the river Krishna	The Talcher Dhamra stretch of river Brahmani, Geonkhali Charbatia stretch of East Coast Canal, Charbatia Dhamra stretch of Matai river and Mangalgadi Paradip stretch of Mahanadi delta rivers
Length in km	1620	891	205	1078	588
States through which it passes	Uttar Pradesh, Bihar, West Bengal	Assam	Kerala	Andhra Pradesh, Tamil Nadu, Pondicherry	West Bengal and Orissa
Least Available Depth in meters	Haldia (Sagar) - Farakka (560Km) - 3m Farakka - Barh (400KM) - 2.5m Barh - Ghazipur (290KM) - 2m Ghazipur – Chunar/Allahabad (370KM) - 1.5m	Bangladesh Border - Pandu (255 km) - 2.5m PanduNeamati (374 Km) - 2.5m NeamatiDibrugarh(139 km) - 2m DibrugarhOriumghat (92 Km) - 1.5m	2 m has been provided in the entire NW-3	Under Development	Under Development. To maintain LAD of 2 m in the Brahmani river all through the year
Type of cargo	Cement, Fly Ash, Iron Ore, Coal, Tyres, Steel Plain Sheet, Stone Chips, Petroleum Products, Grains Aluminium block, Coke, Cooking coal.	Bamboo, Bamboo products, Coal, Plant & machinery, Cement, Building material, fertilizer, Food grains, Milk & other essential commodities	Phosphoric Acid, Sulphur, Zinc, Furnace oil, Rock Phosphate, Various commodities in containers, Furnace oil bunkering, POL(bunkering to ships), Potable water	-	-

Table 2 Details of operational NWs

Sl.No.	NWs	Length (Km)	Location
1	NW 1: Ganga-Bhagirathi-Hooghly River System (Haldia - Allahabad)	1620	Uttar Pradesh, Bihar, Jharkhand, West Bengal
2	NW 2: Brahmaputra River (Dhubri - Sadiya)	891	Assam
3	NW 3: West Coast Canal (Kottapuram - Kollam), Champakara and Udyogmandal Canals	205	Kerala
4	NW 4: Phase-1development of the stretch Muktiyala to Vijyawada of river Krishna	82	Andhra Pradesh

5	NW10: Amba River	45	Maharashtra
6	NW 83: Rajpuri Creek	31	
7	NW 85: Revadanda Creek - Kundalika River System	31	
8	NW 91: Shastri river–Jaigad creek system	52	
9	NW 68: Mandovi – Usgaon Bridge to Arabian Sea	41	Goa
10	NW 111: Zuari– Sanvordem Bridge to Marmugao Port	50	
11	NW 73: Narmada river	226	Gujarat & Maharashtra
12	NW 100: Tapi river	436	
13	Sunderbans Waterways NW 97: Namkhana to AtharaBankiKhal in West Bengal.	172	West Bengal (through Indo-Bangladesh Protocol Route)

cargo volume, in terms of tonnage, in 2019-20. It had been reported that there was an increase of 7.7%, in terms of tonnage km, in 2017-18 compared to that of report obtained in 2016-17 whereas in 2019-20, there was a decrease by 6.36%, in terms of tonnage km, as against 2018-19. Table 3 [21] shows cargo movement on inland waterways in India for the three years 2017-18, 2018-19 and 2019-20.

IWAI reported that there was an exponential growth of traffic on Inland Waterways in the last four years with Compound Annual Growth Rate (CAGR) of 10.81% and reached to 83.61 million tons in the year 2020-21, despite the pandemic situation. The comparison of cargo movement over the three Financial years from 2018 to 2021 is given in Table 4.

Witnessing the potential from Table 4, IWAI aims at increasing the modal share of freight movement through IWT from 2% to 2.5% by the year 2030.

V. INLAND VESSELS

The number of vessels deployed and volume of cargo carried on Inland Waterways across the reporting States and UTs is given in Table 5. The total number of vessels in the States during 2019-20 was 10785 which is lower as compared to 11155 vessels in the year 2018-19. Kerala has reported the highest number of vessels 5590 followed by West Bengal (2381), Maharashtra (1663), Gujarat (454) and Goa (244). However, the volume of cargo handled through these vessels in the year 2019-20 was 509671.76 thousand tonnes. Assam has reported the highest cargo handled through waterways which was 367669.60 thousand tonnes followed by 56725 thousand tonnes through West Bengal. In India, there are three major types of vessels found in the inland water transportation namely Cargo barges, Tugs and Passenger crafts. Cargo barges of length 50 - 90 m employs engine capacity of 400 - 1500 Bhp consumes 50 - 150 litre per hour, Tugs of length 15 - 50 m employs engine capacity of 400 - 4500 Bhp

Table 3 Cargo Movement on Inland Waterways of India

Sl.No.	Waterways	Cargo Moved (Lakh Tonnes)			Tonnes Kms (in Lakh)		
		2017-18	2018-19	2019-20	2017-18	2018-19	2019-20
1	NW 1	54.79 (10.9)	73.49 (10.91)	91.12 (13.29)	27773 (67.2)	29003.84 (61.2)	30544 (68.77)
2	NW 2	31.62 (6.3)	28.72 (4.26)	3.93 (0.57)	614.69 (1.5)	561.00 (1.2)	79.34 (0.18)
3	NW 3	4.28 (0.9)	4.20 (0.6)	5.46 (0.80)	81.14 (0.2)	88.30 (0.18)	101.97 (0.23)
4	NW 4	-	4.50 (0.7)	0.82 (0.12)	-	10.00 (0.02)	-
5	Goa Waterways	111.62 (22.3)	37.72 (5.6)	29.52 (4.31)	5581.06 (13.5)	1886.4 (4.0)	1476.05 (3.32)
6	Maharashtra Waterways	183.37 (36.6)	203.98 (30.3)	209.52 (30.58)	5520 (13.4)	5972 (12.6)	1571 (3.54)
7	Gujarat Waterways (from October 2017)	115.20 (23.0)	288.20 (42.8)	310.15 (45.27)	1728 (4.2)	4300 (9.0)	4652 (10.48)
8	Sunderban Waterways	-	32.3 (4.8)	34.61 (5.06)	-	5600 (11.8)	5988 (13.48)
	Grand Total	500.88	673.11	685.13	41297.89	47421.54	44412.36

Source : (i) Inland Waterways Authority of India for National Waterways , Gujarat Waterways & Sunderban Waterways
(ii) Data for Goa Waterways include the data received from Ports department, Govt of Goa and the data received from the Mormugao Port Trust (MPT).
(iii) Maharashtra Maritime Board for Maharashtra Waterways.

Note : 1. Cargo handled in Kolkata-Bangladesh-Kolkata route is included in the traffic on National Waterway No. I. The route is a link between NW-I & NW-II through Bangladesh
2. Figure within brackets indicates percentage to the total.

consumes 50 - 550 litre per hour and Passenger ferries of length 20 -30 m having engine capacity of 100 - 200 Bhp consumes 20 - 50 litre per hour. The number of cargo barges, tugs and passenger crafts running across various states of India is shown in Table 6 [23].

Table 4 Comparison of cargo movement from 2018 to 2021

NWs	Quantity in tonnes		
	2018-19	2019-20	2020-21
NW 1 (Ganga-Bhagirathi-Hooghly River System)	67,93,981	91,13,297	92,06,984
NW 2 (Brahmaputra River)	5,02,003	3,92,768	3,07,191
NW 3 (West Coast Canal)	4,08,790	5,46,051	7,33,977
NW 4 (Krishna Godavari River Systems)	4,52,066	82,226	68,31,824
Maharashtra Waterways			
NW-10 (Amba River)	2,23,81,100	2,20,14,466	1,76,85,737
NW-83 (Rajpuri Creek)	8,16,205	6,66,755	2,05,567
NW-85 (Revadanda Creek-Kundalika River System)	17,69,947	15,92,477	10,83,701
NW-91 (Shastri River - Jaigad Creek System)	33,74,399	1,19,443	92,34,983
Goa Waterways			
NW-68 (Mandovi River)	16,53,751	15,75,640	39,96,431
NW-111 (Zuari River)	21,04,219	13,58,202	44,64,662
Gujarat Waterways			
NW-73 (Narmada River)	40,941	99,614	82,311
NW-100 (Tapi River)	2,87,80,183	3,09,16,062	2,56,29,554
NW-16 (Barak River)	-	4,417	1,032
NW-44 (Ichamati River)	-	8,98,641	2,80,353
NW-94 (Sone River)	-	8,00,000	0
NW-97 (Sunderbans Waterway)	32,27,460	34,59,540	38,61,439
NW-86 (Rupnarayan River)	-	0	1443
Grand Total Metric Tonnes	7,23,05,045	7,36,39,599	8,36,07,189
Grand Total Million Metric Tonnes	72.30	73.64	83.61

Table 5 State-wise number of inland vessels and cargo carried

State/UT	Number of Vessels				Volume of Cargo Carried (thousand tonnes)			
	2016-17	2017-18	2018-19	2019-20	2016-17	2017-18	2018-19	2019-20
Assam	187	191	198	203	3871.07	706066.16	272873.15	367669.60
Bihar	138	138	138	138	2.40	2.40	2.40	2.40
Goa	311	266	250	244	116600.8	71902.10	14839.4	8200
Karnataka	66	66	66	37	29.98	93.27	0	24.45
Kerala	5556	7656	5953	5590	326.64	447.98	262.35	56098.80
Maharashtra	384	1166	1391	1663	17642.72	18336.59	20397.93	20951.51
Orissa	557	635	335	73	-	-	-	-
West Bengal	2155	2216	2327	2381	22654	36719	46930	56725
Tamil Nadu	2	2	2	2	-	-	-	-
Gujarat	-	-	495	454	-	-	-	-
Total	9356	12336	11155	10785	161127.6	833567.5	355305.2	509671.76
Source: Govt. of States & UTs								

Table 6 Number of inland vessels running across various states of India

Sl.No.	State	Cargo Barges	Tugs	Passenger Crafts
1	Gujarat	400-500 Nos.	150 -200 Nos.	-
2	Maharashtra	400-500 Nos.	200 - 300 Nos.	100 - 150 Nos.
3	Kerala	20 - 30 Nos.	5 - 10 Nos.	40 - 50 Nos.
4	Andhra Pradesh	-	10 - 25 Nos.	15 - 20 Nos.
5	West Bengal	100 -150 Nos.	10 - 25 Nos.	40 - 50 Nos.
6	Assam	3 - 5 Nos.	5 - 8 Nos.	40 - 50Nos.

The average bunker oil consumption by various vessels is given as follows:

Cargo barges : 5 - 7 Kilo litre per month
Tugs : 15 - 50 Kilo litre per month
Passenger Crafts : 2 - 3 kilo litre per month

Apart from the above vessels, total fleet of 200000 fishing trawlers are plying across India. There are some crafts such as tourism crafts of 400 - 500 Nos. in Varanasi and 100 - 250 Nos. in Kolkata and Sunderbans. Sayana, K.A. and Remesan, M.P. [15] analysed about the the average annual fuel consumption of trawlers and observed that it is highest in very large trawlers followed by large trawlers, medium trawlers, small trawlers (multi-day) and small trawlers (single-day).

VI. AIR POLLUTION FROM INLAND VESSELS

Maritime sector is a major source of air pollution because of emissions from it. Especially, in harbour based cities, emissions from ships become a dominant source of air pollution and it widespreads across several kilometers in the atmosphere. Generally, all shipping activities result in air pollutant emissions [18]. Most of the shipping vessels use heavy fuel oil with high sulphur content. The emissions from burning such a fuel consists of Sulphur dioxide (SO_2), Nitrogen oxides(NO_x), Voltaile Organic Compounds(VOCs), Particulate Matter (PM), Carbon Dioxide (CO_2) and other Green House Gases(GHGs) [1]. The emissions from engines is directly related to fuel consumption of engines, which in turn depends on different factors such as hull shape, loading conditions, engine condition, etc. Moreover, in port areas, more harmful pollutants such as particulate matter, O_3, NO_2, SO_2, CO and Pb and NO_x are resulted from shipping operations. In world's total CO_2 emissions, shipping is considered to be the major contributor. According to IMO(2009), 870 million tonnes of CO_2 emissions in 2007 would be increasing by a factor of 2.2 and 3.3 in 2050. Dat Nguyen et al. [3] did research on emission inventories in the Red River in Hanoi(Vietnam) and estimated seven pollutants using SPD-GIZ emission calculation model. They have found from thier research that CO_2 has the most significant contribution to the gas volume emitted and also the bulk carriers are the largest emission vehicle, accounting for more than 97% of total emissions. Kazım O et al. [10] made investigations of indoor air quality in city buses in real time traffic and stated that CO_2 is one of the vital factors in determining air quality in the atmosphere. Tai HH and Chang YH [17] proposed activity-based model to estimate the emissions from ships while maneuvering in port. They made their investigations in seven international commercial ports in Taiwan. They studied about the emissions of NO_x, SO_x, CO_2, CHx, and PM_x from different types of vessels and observed that the emissions of SO_x, CO_2 and CH_x were increased when the speed of the vessels was higher.

In India, marine fisheries is a basic livelihood for a large population. Now, this sector faces many issues such as pollution and habitat degradation. One of the major issues in fisheries is climate change because of emission of GHGs from engines. Marine fisheries use the following types of vessels: mechanised boats, motorized boats and non-motorized traditional boats [20]. The most frequently used boats for fisheries are falling under the first two categories. They consume more fuel and eventually leads to more GHGs emissions. Another important consideration in the aspect of more emission is that the increase in number of mechanised and motorized boats used for fisheries. The increase in number of boats during 1961 - 2010 is given in Table 7.

Table 7 Increase in number of boats during 1961-2010

Year	Mechanised boats of various lengths	Motorized boats	Total
1961	6708	0	6708
1973	8086	0	8086
1980	19210	0	19210
1998	49070	50922	99992
2005	58911	75591	134502
2010	72559	71313	143872

Table 8 CO_2 emission by different craft types in 2010

Craft	Fishing hours (million)	Catch (mt)	Catch rate (kg/h)	CO_2 emission (mt)	Emission rate (kg/h)	Emission intensity (t Co_2/t catch)
Mechanized craft						
Trawler	35.58	1.58	44.4	2.260	63.5	1.43
Gillnetter	13.60	0.21	15.4	0.190	14.0	0.90
Bagnetter	0.96	0.05	52.1	0.047	49.0	0.94
Dolnetter	7.52	0.35	46.5	0.376	50.0	1.07
Liner	0.29	0.01	34.5	0.007	24.1	0.70
Seiner	3.95	0.40	101.3	0.250	63.3	0.63
Others	0.80	0.09	112.5	0.050	62.5	0.56
Motorized craft						
All gear	26.12	0.71	27.2	0.420	16.1	0.59

Non-motorized craft						
All gear	12.11	0.13	0.01	-	-	-
Grand Total	100.93	3.53	35.2	3.600	35.7	1.02

It is observed from Table 7 that the number of mechanised boats increased from 6708 in 1961 to 72,559 in 2010. Also, it is estimated that the mean engine horse power of mechanised boats had been increased from 55 hp in 1961 to 122 hp in 2010 with an increase of about 2.2 times the fishing efficiency over the 50-year period. After motorized boats came in to existence, the fishing efficiency had been increased by 27 times. Simultaneously, the CO2 emissions per tonne of fish caught increased from 0.50 t in 1961 to 1.02 t in 2010 [19]. That is, the CO2 emission had been doubled for every tonne of fishing in 2010 compared to that in 1961. Further, Table 8 shows the CO_2 emission by different craft types in 2010.

Apart from CO_2 emission, other emissions such as SO_x, NO_2 and PM are also being accounted for air pollution. Marine fuels are generally categorized as fuel oil or distillate, which refers to the residual fuel oil. This type of residual fuel is commonly termed as Heavy Fuel Oil (HFO), which contains significant amount of sulphur. The average sulphur content is 2.7% mass, which is 90% higher than conventional petrol or diesel [2]. SO_x emission is directly proportional to the sulphur content present in the fuel. In order to reduce the sulphur content, the following ways are suggested.

i) Low-sulphur fuels, which contains less than 10,000 parts per million (ppm) of sulphur, 1%

ii) Ultra-low sulphur fuels, which contains less than 300 ppm sulphur, 0.03%

iii) Alternative fuels (biofuels, natural gas and hydrogen)

iv) Distillate fuel. Distilling fuel reduces its SO_x by 80% and its PM by 35%. However, distillate fuels increase CO_2 emissions up to 20%.

v) Water emulsified fuel. It is believed to reduce the NO_2 production, hydrocarbons and PM formation.

Chapter IX of IV ACT 2021deals with the preventive measures of pollution caused by inland vessels. It ensures the standards of construction, installation and maintenance of equipment of all mechanically propelled inland vessels. It emphasizes that all mechanically propelled inland vessels should carry on board a valid certificate of prevention of pollution, issued by the State Government. In order to prevent pollution, this act insists the owner or operator of all cargo terminals or passenger terminals to provide reception facilities to discharge oil, oily mixture, hazardous chemicals, sewage or obnoxious substances at such cargo or passenger terminal. It lacks to address the issue of ship emissions from engines and the prevention of air pollution due to this emission.

VII. CONCLUSIONS

Water transportation is the cost effective mode of transportation compared to roadways and railways for the movement of large-scale cargo. Because of having wide network of national waterways in India, the government is investing more to develop the waterways for domestic shipping. Government of India identified 13 operational NWs for shipping and navigation and cargo/passenger vessels. Further, more navigable waterways are being identified and developed. National Waterways of India and Cargo movement over these waterways have been discussed in this study. IWAI reported that there was an exponential growth of cargo movement on inland waterways from 2018 to 2021 in India. It aims at increasing the modal share of freight movement through IWT from 2% to 2.5% by the year 2030. The impact of operating inland vessels on environment especially air pollution is mainly focused in this study. Because of using high power engines operated with heavy oils for carrying huge amount of cargo, there would be emissions from burning such a fuel consists of SO_2, NO_x, VOCs, PM, CO_2 and other GHGs. This emission from ships become a dominant source of air pollution and it widespreads across several kilometers in the atmosphere. It is reported in this study that the number of vessels is increasing by leaps and bounds every year based on the trade requirement. It shows that the air pollution from inland vessels will be increasing time to time and will affect the climatic condition of the country.

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