Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/7318
DOI URL: http://dx.doi.org/10.21474/IJAR01/7318

RESEARCH ARTICLE

WASTE GENERATION AND MANAGEMENT IN ANTHROPOCENE EPOCH: AN OBJECTIVE APPRAISAL OF INDIAN CONDITION

Dr. Siba Prasad Mishra and Dr. Durga Prasad Mishra.
1. Associate Professor, Centurion University of Technology and Management, Jatni, Bhubaneswar, Odisha.
2. Chief General Manager, The STC of India Ltd, Nilhat House, 9th Floor, R N Mukherjee Road, Kolkata.

Manuscript Info

Manuscript History

Received: 18 April 2018
Final Accepted: 20 May 2018
Published: June 2018

Keywords:-
Anthropocene, e-wastes, Nano wastes, C&D wastes, demography, India.

Abstract

The Anthropocene epoch is the age of waste of human usages, which are the typical relics of innovation leading to climate change or the near mass extinction. The wastes are in solid, liquid, gaseous or remediated forms and the volume and varieties are ever-increasing. The Anthropocene epoch is the novice geological era with human exploitation on soil, nature, space, and geology with unlimited spoils. The epoch is marked by the excess use of natural and synthetic materials like fossil fuels, aluminum, concrete, plastic, fly ash and upshot from nuclides from nuclear explosion, $CO_{2,}$ GHG emissions due to wastes. Fly-ash, metallurgical slags, sludge from wastewater treatment plants (WTPs), dried sewage and sludge, agro-wastes, plastic & other packaging materials of industrial origin amounting to ≈ 200MMT is added to the environment annually in India which is mostly non-biodegradable CPCB (2017). All stake holders like government, non-government agencies, including civil society in India should make concerted effort to confront the anthropogenic non-biodegradable wastes mainly the industrial, plastics, nano, C&D and e - wastes. The study analyses different types of wastes based on statistics both in the global and Indian scenario. The shortage in landfill area for efficient disposal is the concern and micro-level management of such wastes are discussed.

Introduction:-

Waste materials have no immediate use, need, value, economically redundant and the user wants its immediate disposal (WHO). Waste can be solid, liquid, gasses, electrical and electronic waste (e-waste), and. radioactive waste Environmental Protection Agency (EPA), the U.S. delineates waste as any garbage/trash, sludge from flora and fauna with many needless kinds of stuff in solid, aqueous or gaseous form and consequential output from anthropogenic, commercial, community, industrial, mining, and agricultural activities. Garbage junkyards adversely impact local food chain leading to extinction of certain flora and fauns in the eco system of that particular area.

Since the evolution of Homo sapiens, i.e.1.6 MYBP, human used to dwell in very small nomadic groups and sustained on hunting. Warm weather combined with heavy rainfall (from early Holocene, ≈ 12,000 YBP), encouraged them to shift to agriculture. Civilization flourished near water bodies with permanent settlement leading

Corresponding Author:- Siba Prasad Mishra
Address:- Associate Professor, Centurion University of Technology and Management, Jatni, Bhubaneswar, Odisha.

to complex civilization to date. The ancient civilization had produced perishable and biodegradable wastes then. The then atmosphere was maintained at a constant CO_2 level of about 300ppm.

At present the world's population is about 7.6 Billion (2018) (Worldo meters), out of which the urban demography is 4.034 Billion, (54% of total) living in 2049 towns (population > 0.5million) (UN, 2016) generated average waste @353 Kg/C./year when the average (av.) urban GDP was 22760 USD/capita in 2013 (IEA, The International Energy Agency), OECD/IEA data (2013). The growth of technology in 20th century taught human civilization the fossil fuel use. With rapid urbanization and industrialization of India, over 377 million urban people lived in 92 towns with population >0.5million, (Census 2011) which generate 62 MMT/annum of municipal solid waste, Planning Commission, India Report (2014). It is reported only 43 MMT of the waste could be collected and about 11.9 MT waste could be treated and balance 31 MT waste was dumped as landfill in India Joshi et al., 2016 and Laihiri S. (2017). The type of wastes generated in the present Anthropocene epoch is given in Fig 1.

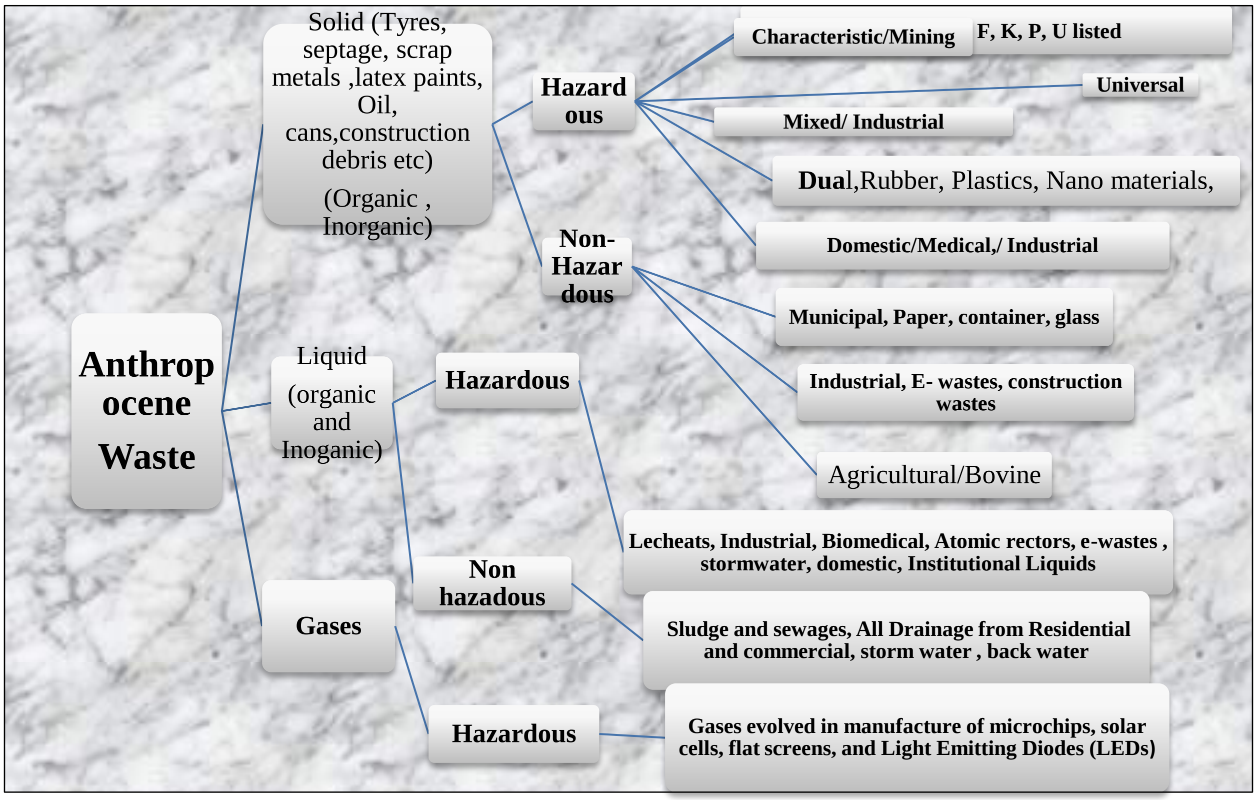

Fig 1:-Different types of wastes, their effectiveness and sources of evolvement

Review of literature:-

Alemayehu E., 2004 have suggested collecting waste in residential areas during the day and in commercial areas during the night. Sharholya M, 2008 have mentioned that about 90% of Municipal solid wastes (MSW) is disposed of untreated innate in exposed dump yards and landfills, crafting glitches to public health and surroundings. Ghosal T., et al (2008) have estimated that 1.039 MMT of Carbon is generated from different manufacturing plants in India in the year 2003. Present geological epoch, the Anthropocene considered to be human-directed Ellis (2009, 2011, 2012), Paul Randell, 2012 reported that the liquid and solid waste data should be taken simultaneously for the convenience of study. Only 9% of the plastic waste is recycled and rest 5.733 BMT of plastic is gone to the soil and major portion finally join the sea Annepu R. K. 201 http://home.iitk.ac.in/~anubha/H13.pdf. Raghab et al (2013) have verified that Perlite is a better accelerator with alum to enhance treatment of Leachate than bentonites. Crutzen and Steffen (2003), Crutzen et al., (2011) and Zalasiewicz et al 2014**.** Madaan N., 2015 reported in TOI that Maharashtra, Uttar Pradesh, Tamil Nadu and (AP+ Telangana) generated 26.82, 19.18, 14.53 and 11.50 thousand MT of MSW on 6th Feb 2015 respectively. Agrawal R., 2015 quoted from CPCB report that in 1998 that solid waste created in cities of India had increased @ 4.25%/annum from 6MMT in 1947 to 48 MMT in 1997. Singh et al., 2016, reported that about 90MMT of MSW is generated by Indian cities which is about 8 times more preindependence era. These wastes are anthropogenic from industries, mines, municipalities, agricultural and other anthropogenic activities. Yadav et al 2016 have reported that the wastes in India have low components of hazardous components and less environment threatening. The regulation policy is only available for plastics but not for E-wastes. The formation of solid wastes in Indian Municipalities are organics 50-57%, recyclables 16-19% (paper, plastic, metal, E wastes and glass) and inert 28-31 %. The moisture content is 47% and the average energy value is 1620-2340 kcal/kg. Lahiri S., 2017 reported that the developing smart cities should stress upon to build the proper solid and liquid waste management / control architecture. Choudhury M., 2017 have quoted that 4.4 BMT solid wastes are generated annually in Asia out of which municipality solid waste (MSW) is 790MMT. MSW amounts to 48MMT (6%) India generates which may rise to 300MMT by 2047 (@1.2 kg to 1.42 kg per capita) and 169.6 Km^2 landfill area shall be required. Laura Parker from National Geographic, 2017 has reported that the earth has manufactured 8.3 BMT of Plastic in the year 2016 (may go up to 12BMT by 2025) and waste generated in that period is 6.3 BMT. Research in 249 lakes of China reveals that the Dissolved Organic Carbon, (DOC) due to uses of fertilizers and Dissolved inorganic carbon (DIC) are due to the presence of different salts in water is increasing continuously at present Song et al., 2018.

The aim of the study:-

The barrier between nature and culture has been removed at present by domesticating flora, fauna and aqua habitats on earth. The Earth is marching fast towards a bald, warmer, wetter biome. Homo sapiens are the best geo-engineers who reshaped their geo, hydro and biosphere. The Anthropocene epoch (the age of humans) has dethroned the 11650 years existent "The Holocene". The GSSP and the GSSA (Global Boundary Stratotype Section and the Global Standard Stratigraphic Age) has fixed the demarcation between the Holocene and the Anthropocene epochs on 16^{th} August 1945, the world's 1^{st} nuclear explosion at Alamogordo, New Mexico Zalasiewicz et al 2014. After 35years the earth had started experiencing the acute impact of the anthropogenic activities (1980 AD onwards). The period of great acceleration (Golden Spikes) started in India Mishra S. P. 2017. Homo sapiens were in the comfortable zone during the Holocene epoch with good rain and mild summer but we are marching towards a good Anthropocene, where the human race has subdued the earth followed by the shadow of a catastrophe due to various type of wastes, Brunnengräber et al., 2017. One of the major area of concern during Anthropocene is the disposal of the huge volume of wastes generated from the anthropogenic activities.

Solid Waste Statistics:-

Municipal Solid Waste (MSW) generation is ranging from 200 to 870 gm/C/day at present depending upon the modern lifestyle, population density, GDP, climate and topography of the place. It is increasing @ 1.3%/annum against 3-3.5% /annum rise in urban population Mohanty et al 2014. The MSW produced in the globe during the year 2016 was 1.3 BMT which may rise to 2.2 BMT by 2025 (World Bank report). The growth in urban settlements had doubled generation of solid waste to @1.2 Kg/C /day from 0.64 Kg/C /day within a decade. The waste generation projected to rise to 1.42 Kg/ C/day in 2025 which is faster than population growth in 2013, https://waste-management-world.com/a/ interactive- map-worlds-most- wasteful-countries). Total waste had increased from average 680 MMT/year in 2006 to 1300MMT /year 2015. It is also alarming that some islands like Guyana, Kuwait, St. Kitts and Nevis and Ceylon generate wastes more than 5Kg/C/day of MSW followed by Solomon Island and St. Lucia @ >4Kg/C/day. The plot between the population growth and the amount of solid waste generation (the population is >20million or @ generation is >0.5 kg/C/day) in some developing countries during Anthropocene Epoch (2016 and projected 2025). The country-wise population growth has been shown in **Fig 2**.

Anthropocene wastes:-

Homo sapiens have triggered the climate changes by various anthropogenic activities. CO2, which was at equilibrium, @280ppm from 1850 have risen to 400 ppm in 2015. Most of the upsurge of the humane forcing had started from 1980's and average temp rise of 0.90 C due to global warming started since 1850. Over the past 40 years, human activities have damaged the world's ecosystems more hastily and broadly than in any other period in past. The International Commission on Stratigraphy agreed that the Capitalocene designate a new geological epoch. The Homo sapiens are bringing the nature to the brink of extinction through waste, Fremaux Anne, 2017. More nitrogen are exploited in agriculture sector due to excess fertilizer utilization, fossil fuel combustion and exponential rise in exploitation of resources due to population explosion growth. The earth is in its sixth great extinction event and species loss is growing rapidly for both terrestrial and marine ecosystems Mishra S. P., 2018.

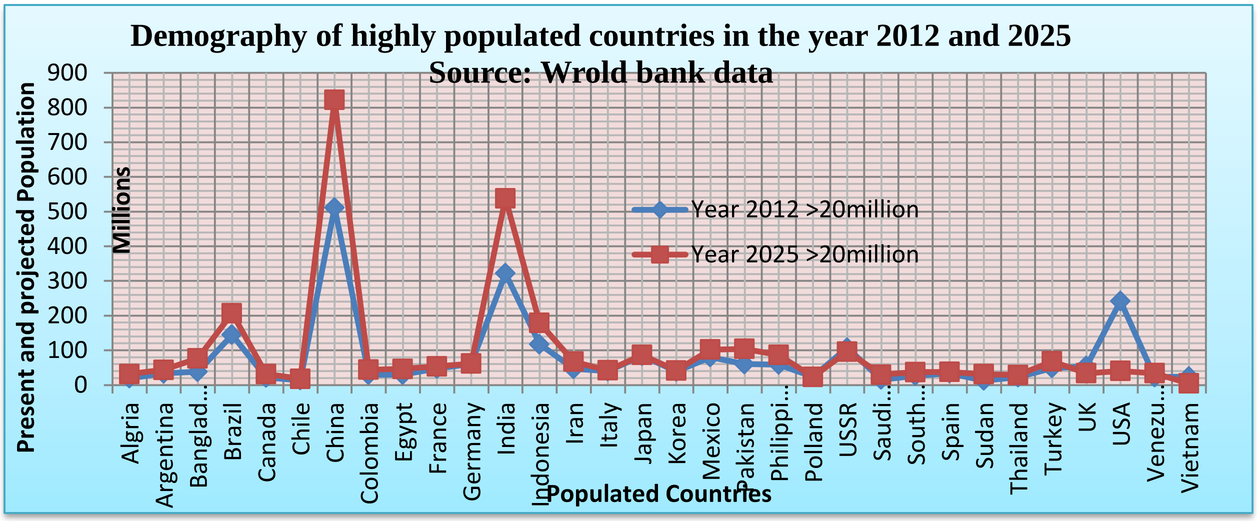

Fig 2:-The past (2012) and projected (2025) global demography of populous countries

The concern in the present epoch is that some advanced countries like New Zealand, Ireland Norway and Switzerland are generating wastes @ 3.68 Kg/C/day, @ 3.58 Kg/C/day, (@ 2.80 Kg/C/day, and @ 2.61 Kg/C/day respectively. The highest contributor of solid waste in the year 2012 was the USA ~~in~~ with total waste of 624700 MT/day @ (2.58 Kg/C/day) and the projected solid waste during 2025 shall be 701709MT/day (@ 2.3 Kg/C/day) **(Fig 3)**

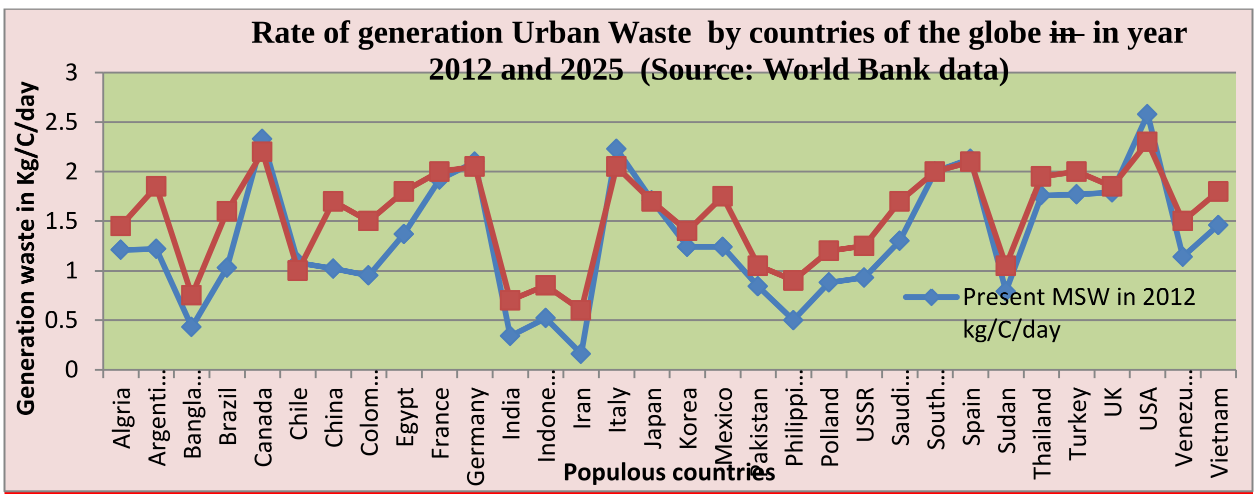

Fig3:-Generation of MSW (Kg/cap./day) in some populous countries (2016 & 2025)

The average rate of generation of per capita (cap) municipal urban waste on earth was 1.277 Kg/C/day during the year 2016 and same projected to be @ 1.53 Kg/C/day during the year 2025.and the total MSW projected to be 3.09MMT/day as per World Bank data 2016. The waste generation of those countries was projected to @1.53Kg/C/day and total waste generated shall be 5.27MMT/day by World Bank 2016. The rate of rising in population within 9 years shall be @ 31.17%, the generation rate/C/day of MSW shall increase by 19.48% and the total amount of MSW to be handled shall increase by 70.44%/day being double the population growth rate. http:// site resources World bank.org/inturbandevelopment/Resources/336387-1334852610766/AnnexJ (**Fig 4**).

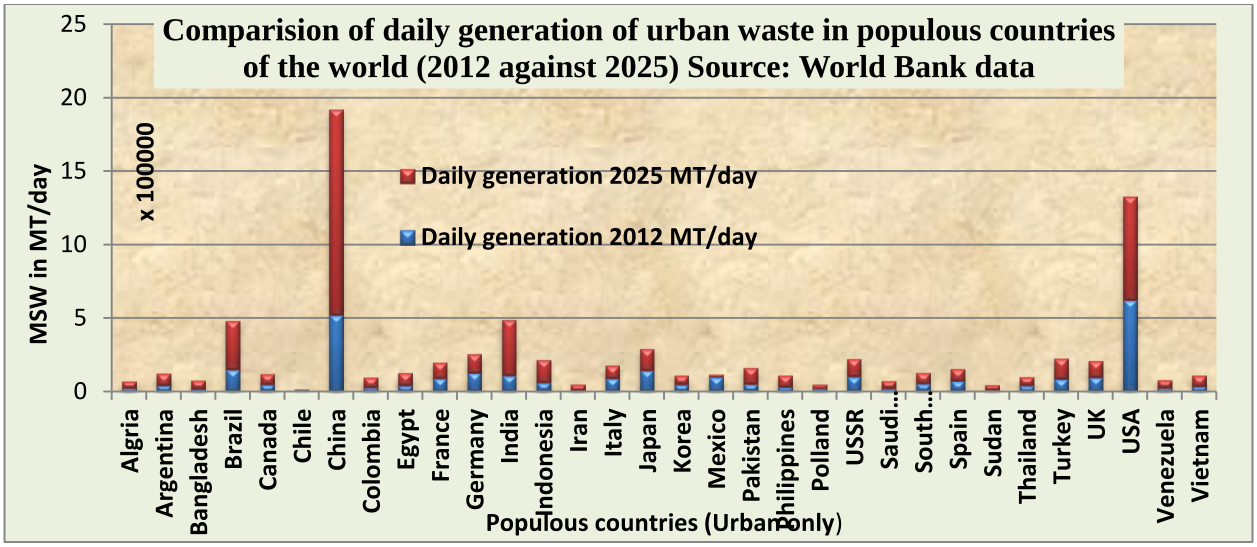

Fig 4:-Comparison of daily generated MSW in populous countries Source: World Bank data

The generation of low average rate of MSW in SAARC (The South Asian Association for Regional Cooperation) countries is 70 MMT/annum @ 0.45 kg/C/day. It is due to non-inclusion of huge mining and C&D wastes in the statistical reports. There shall be an increase in waste generation (if mining and C&D wastes included) in India and the management of MSW shall pose a herculean task for the globe in general and for India in particular.

Population and Solid Waste, India:-

About 377 million people (≈31% of total population of India) live in 7935 municipalities/Towns/UAs/OGs (Census of India, 2011). About 7.4 MMT of hazardous wastes is generated annually in India out of which 3.98 MMT is recyclable and reusable. The rest of hazardous waste are required to be dumped in landfills scientifically **(Fig 4).** Reportedly Indian generate > 42.0 MMT of MSW annually CPCB reported in 2017 that MSW generated in India was ≈65 Mio TPA out of which 15-20 % was non-recyclable. The amount of solid wastes tends to increase by 25% to 35% during festive occasions. The volume and varieties of MSW are continuously increasing with growth in population. The number of Notified Area Councils (NACs) and municipalities in the country has increased from 5,161 (2001) to 7,935 (2011). Thus generation of MSW had increased with the increase in ~~a~~ number of townships and scattered human settlements.

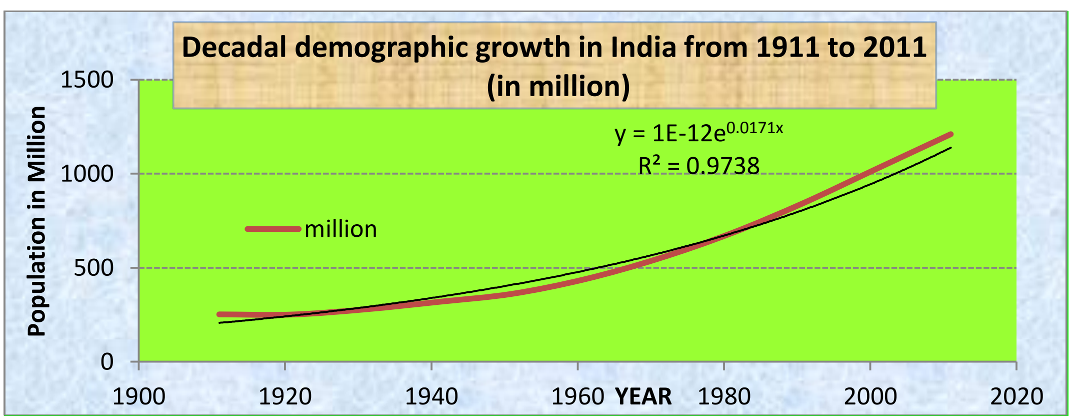

Fig 5:-Decadal demographic growth in India (Source: Census data India)

India is the 2nd highest populous countries of the globe having a present population of about 1.35 Billion (2018) next to China with 1.42 billion population. India has 53 megacities, having population > 1000000, 397cities between 100000 to 1,000,000 and about 2500 urban areas with population < 100000. Metro cities in India is generating huge MSW annually that include Ahmedabad (6.3 MMT), Hyderabad (7.7 MMT), Bangalore (8.4 MMT), Chennai (8.7

MMT), Kolkata (14.1 MMT), Delhi (16.3 MMT) and Greater Mumbai (16.4 MMT) **Fig 6**. These megacities have registered exponential economic growth **(Table 1 and Fig 5)** and have reported huge per capita waste generation,

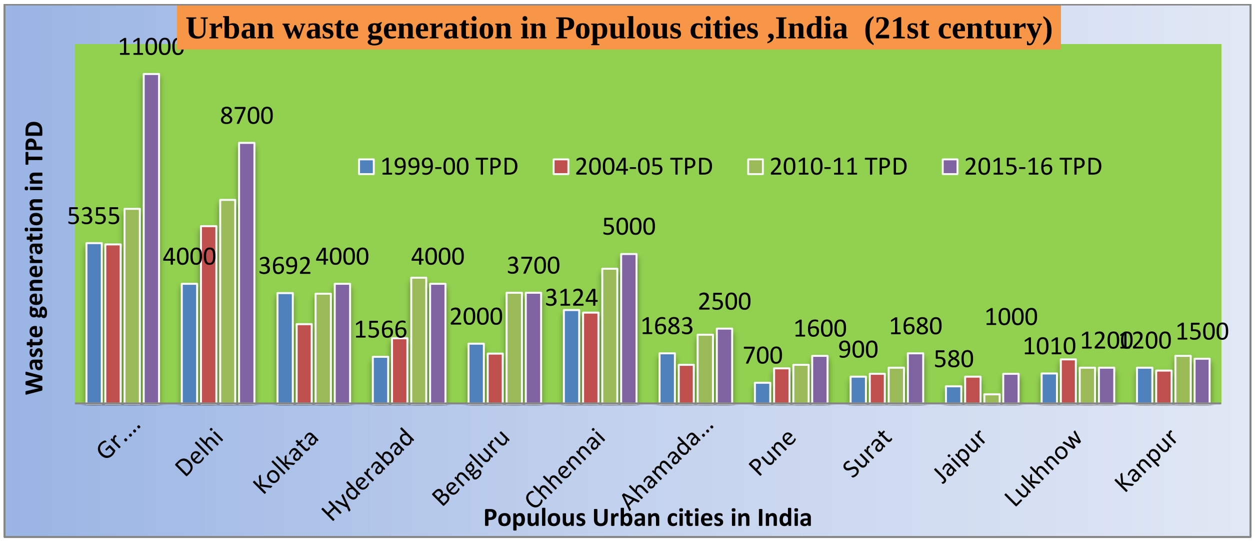

Fig 6:-Urban waste generation in Populous cities at 5years interval, India (21st century)

Waste generation in Urban and Rural areas:-

High waste generating states in India are Maharashtra (115 364–19 204 TPD), Uttar Pradesh, Tamil Nadu, W.B. (11 523–15 363 TPD), A.P., Kerala (7683–11 522 TPD) and MP, Rajasthan, Gujarat, Karnataka, and Mizoram (3842–7662 TPD). Lower waste generating states are JK, Bihar, Jharkhand, Chhattisgarh, Odisha, Goa, Assam, Arunachal Pradesh, Meghalaya, Tripura, Nagaland, and Manipur (< 3841 TPD), Sanil Ku. et al., 2017. Waste generation depends upon the economic status and lifestyle of the population. The lower socioeconomic group (LSEG), lower middle socioeconomic group (LMSEG) residing in Indian rural areas generate less wastes than the higher socio-economic group (HSEG) Khan et al 2016. It can be safely concluded that the contribution of solid waste from the rural sector is much less than the township areas in India.

As per CPCB report 2000, India, per capita waste generation rate in India were 0.43, 0.39, 0.38, 0.39 and 0.36 (kg/C/day) with demography >2000000, 1000000–2000000, 00000–1000000,100000–500000 and <100000 respectively Western Indian towns generated waste 440 grams/cap/day, eastern Indian cities @500 grams/cap/day, North Indian towns @ 520 g grams/capita/day, and south Indian towns @ 560 grams/person/day. Small advanced states like Manipur generate minimum @220 grams/cap/day and Goa produces maximum waste @ 620 grams/cap/day. Generation of MSW has risen by 2.44 times in last ten years (CPCB, 2013).

Impact of wastes on the environment:-

The immediate effect of wastes in any form can be chemical poison (for inhalation), carcinogenic, causing congenital malformations, low birth rate, neurological diseases, diabetic, nausea and vomiting alongwith flooding/water logging in drains/rivers. The contaminated water affects people's health and the biodiversity. Dumps on exposure increase the risk of negative impacts like the growth of invasive species, pathogens, infectious disease and toxicity. Eutrophication, mercury toxicity, ingestion of plastic in the animals body, depletion of crop yield due to poor and contaminated water/soil, CH_4 (GHG gas) generation from leachates.

Construction and Demolition wastes (C&D wastes):-

The constituents of Construction and Demolition waste (C&D waste) consist of the rubbish created at the time of procurement of building materials, construction, renovation and demolition of monuments, buildings, roads, and bridges *etc.* The concreting volume executed from 1980 onwards for modernization and industrialization is half the total concrete used so far from inception i.e. 1824. The C&D wastes are the excavated materials, concrete, tiles, brick, ceramics, asphalt concrete, plaster, glass, metal, steel, composites, and rubbles, etc. causing dust, noise, smoke and odor (fugitive acquittal). The amounts of C&D waste generated in the world from construction, rehabilitation and demolition of buildings in 2015 were 606548 MT (34%), 557273 MT (31.2%) and 621712 MT (34.8%) respectively (**Fig 7 and Fig 8**).

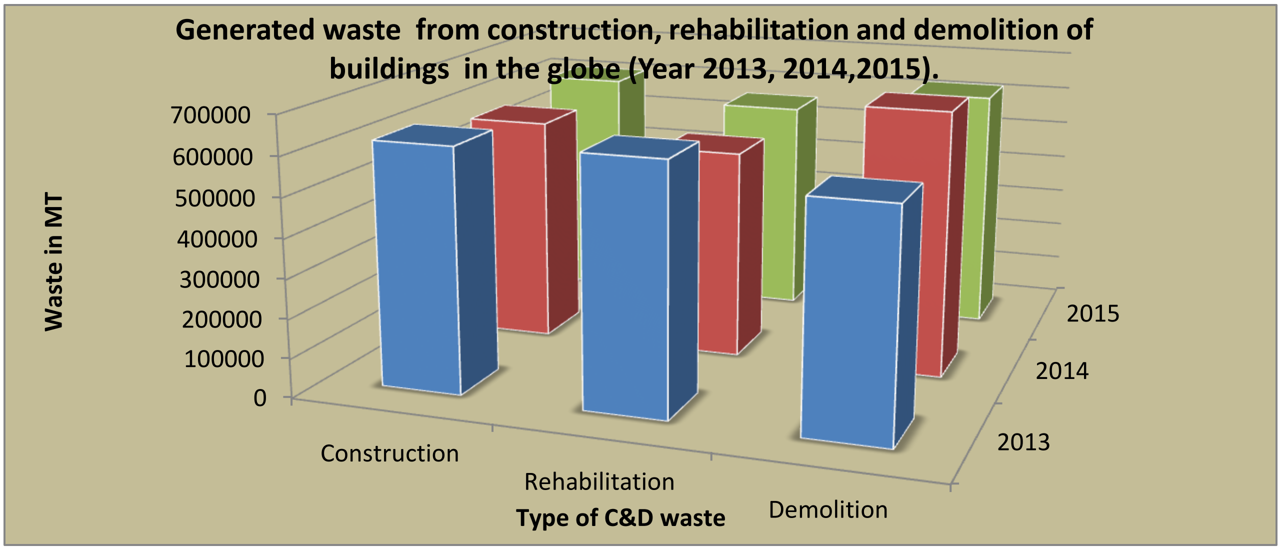

Fig 7:-The Global making of building's waste from construction, rehabilitation, demolition.
(Source:https://www.ssb.no/en/natur-og-miljo/statistikker/avfbygganl/aar/2017-11-20)

CPCB reported in 2015 the reported/projected waste generation in India was 141064 MT/day. The amount collected was 127531 MT/day (i.e. 90%) and 34,752 MT/day (27%) was processed. Construction and demolition (C&D) waste generated from the edifice sector in India was about 12-14.7 MMT in the year 2017 as per CPCB March 2017 and Gayakwad et al 2015. C & D waste is reused and recycled. About 50% of C&D wastes in India were reused, or recycled or replaced while the balance amount is land-filled, Gupta et al., 2018. One-fourth of construction wastes causes disposal problem as they are not biodegradable. Out of the total generation of C&D wastes, only 5% is disposed properly and the rest is dumped either on the roadside or in any landfill. The generation of wastes from mining in India ranges from 700 -900 MMT/year and from energy production 60MMT/year whereas MSW is only 24MMT/year. The mining and a part of C&D waste are not included in calculating the national waste statistics which may be the cause for the low waste generation rate in India

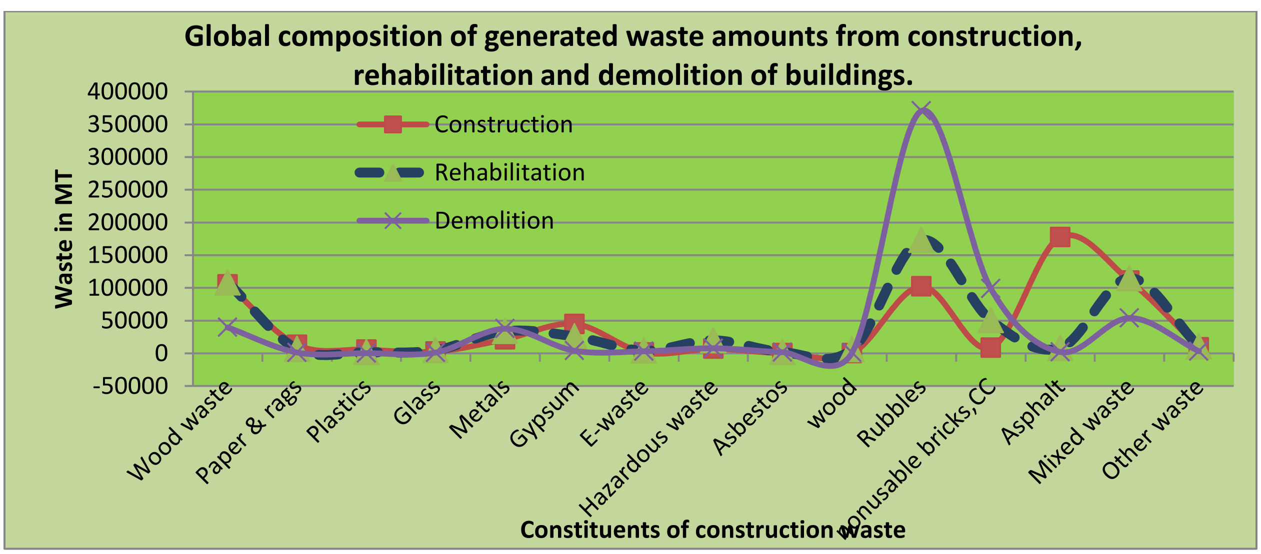

Fig 8:-Global composition of C&D waste from construction, rehabilitation, and demolition

Different researchers tried to evaluate the composition of C&D waste in India. The constituents of MSW and C&D wastes are studied by different agencies like 10-12MT TIFAC 2001, MCD (2004) and IL&FS (2005), 12-14.7 MT by CPCB during 2017 and a total generation of C&D waste between 2005 to 165 to 175MT (BMTC), Manjunath R et al 2017 **(Fig 9)**

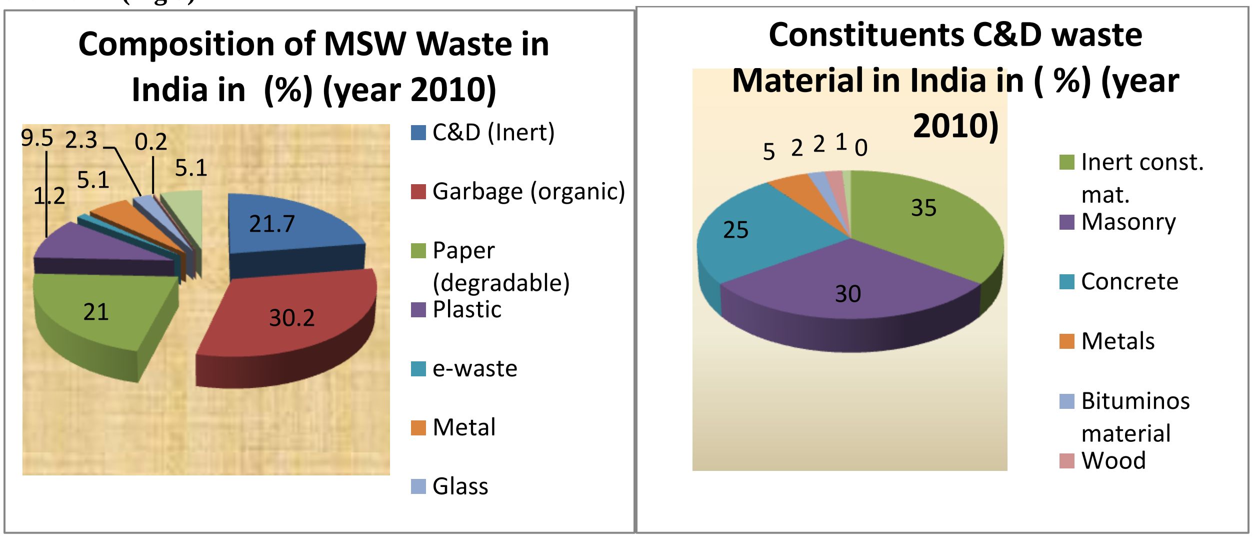

Fig 9:-Composition *of MSW and C&D wastes in India (Source: Manjunath R et. al., 2017)*

Presently, C & D waste generation in India accounts for up to 23.75 MMT annually and these figures are likely to reach double fold by 2016. (Source: International Society of Waste Management, India). According to the Danish Environmental Protection Agency (DEPA), about 70 to -75% C&D waste is generated from demolition activity, 20-25% from renovation activities and the balance 5-10% from new constructions activities (**Fig 8**).

Land Fill in major cities of India:-

The major landfills for disposal of solid wastes should be in safe areas periphery of to the city having no settlement and groundwater (GW) source. The abysmal state of challenges with growing population and increasing urbanization had extended to those areas. Slums have mushroomed growth with rags collectors in and around the landfill areas. The population and landfill areas of major Indian cities are shown in **Table1.** Fly-ash, metallurgical slags, sludge from wastewater treatment plants (WTPs), dried sewage and sludge, agro-wastes, plastic & other packaging materials of industrial origin amounting to ≈ 200MMT is non-biodegradable and added to the environment annually in India CPCB (2017).

Table 1:-Population of major Cities of India, MSW generation, and their Landfill area India

#	Cities	Landfill area	Population 2017	Area	House Hold	GDP ($)	MSW 2015-16	Area of landfill	present /max fill
	Unit	Name	Million	SqKm	‘000	Billion	TPD	Ha	meter
1	Mumbai Gr	Deonar, Gorai, Mulund, Kanjur	16.368	4355	3522	310	11000	150.8	10/22
2	Delhi Gr.	Okhala/Gazipur/ Bhalsa/NarelaBh	16.315	1484	2548	293.6	8700	202	22/30
3	Kolkata Gr.	Dhapa,Garden Reach	14.112	1851	3240	150.1	5372	31.5	30/30
4	Hyderabad	Autonagar	7.749	922	1111	75.2	4200	121.5	05/10
5	Bengluru	Mavallipura	8.499	709	1278	110	3700	40.68	06/13.5
6	Chhennai	Kodungaiyur / Perungudi	8.696	1189	1474	78.6	4500	465.5	NA
7	Ahamedabad	Gyaspur/Pirana	6.352	464	902	68	2300	84	22.5/30
8	Pune	Urali Devachi, Yewalewadi	5.049	331.3	829	69	1678	165	Next 20years
9	Surat	Khajod,	4.585	326.5	574	59.8	1680	200	NA
10	Jaipur	3,046,163	3.046	484.6	409	24	1350	31.4	NA

11	Bhubaneswar	Bhuasuni, Daruthenga	1.553	135	159.5	68	600	83	CPCB report

The composition of solid waste:-

CPBC reported in 2015 that out of total garbage generated Organic garbage constitutes (40-45%) Inert garbage (20-30%) and the balance garbage is mainly of plastics, papers, rags and other components. The composition of biodegradable, recyclable and non-biodegradable determines the efficacy and hazardousness of the solid wastes. The most populous and old cities and their composition of urban solid waste in the present decade are given in **Table 2**.

Table 2: Composition of Municipal Solid waste from 10 major Metros of India

City	Degradable	Paper ,rags /cloth	Plastic/leather/rubber	Metal	Grits/wood /glass	Ash/Soil/ others	Source
Decomposable		Recyclable waste			Inert		
Degeneration period	7-15day	10-30day	undetermined	100-500yrs	undetermined	>2-5year	
Delhi	30.62	5.42	6.14	1.1	14.92	41.8	Gupta et. al., 2016
Mumbai	62.44	7.52	10.66	0.19		17.45	seas.columbia.edu/earth/wtert/sofos/DBSSRS
Hyderabad	48.22	7.26	8.61	2.18	21.42	12.31	
Kolkata	55.06	6.07	4.88	0.53		29.6	Das S. et al., 2013
Chennai	51.34	5	7.86	4	2.1	28.99	Sujtha et al, 12,
Ahmedabad	44	14	10	1	3	28	Jani et al., 2016
Bengaluru	45	13	6	3	6	27	Das et al 2016
Pune	62	8	7	4	6	13	nswai.com/DataBank/pdf/Pune.
Surat	34	15	10	1	2	38	SuratMunicipalcorp
Bhubaneswar	36.23	18.09	10.29	9.68	10.28	16.45	IDCO-III-Project
India	41	10	5	2	2	40	Sunil et al., 2017
World	46	17	10	4	5	18	Hoornweg & Bhada-Tata (2012)

Kolkata municipal corporation area generated, 5372MT/day of waste in 2012 out of which about 1900MT could be recyclable but only 700MT of waste was recycled. These wastes constitute residential (35%), institutional (7%) and commercial (37%) and others (21%) Dutta et al, (2012). The solid waste generated in Indian municipalities like Pune city, organic matter (30–40%), ash and clay (30–40%), paper/ plastic (3–6%) and the E-waste/glass /metal <1%, Dhere et. al 2008.

Plastics Pollution:-

Plastic is a smart, versatile, lightweight, stretchy, moisture resistant, strong, durable, and relatively low-cost product entered the market as a chemical in 1909 and has propagated in all fields of technology. As a non-biodegradable product, a thermoplastic or thermosetting polymer state is a major concern for the aquatic and terrestrial environmental at present. Plastic has become a universal product that has crossed global production of iron from 1990. Application of plastic in domestic, textile, packaging, automotive, infrastructure, agriculture, and electronics has become universal. Global plastic production has increased from 1.5MT in 1950, 311MT in 2014 (Plastic Europe 2015) to 380MT in 2017 **(Fig 10).**

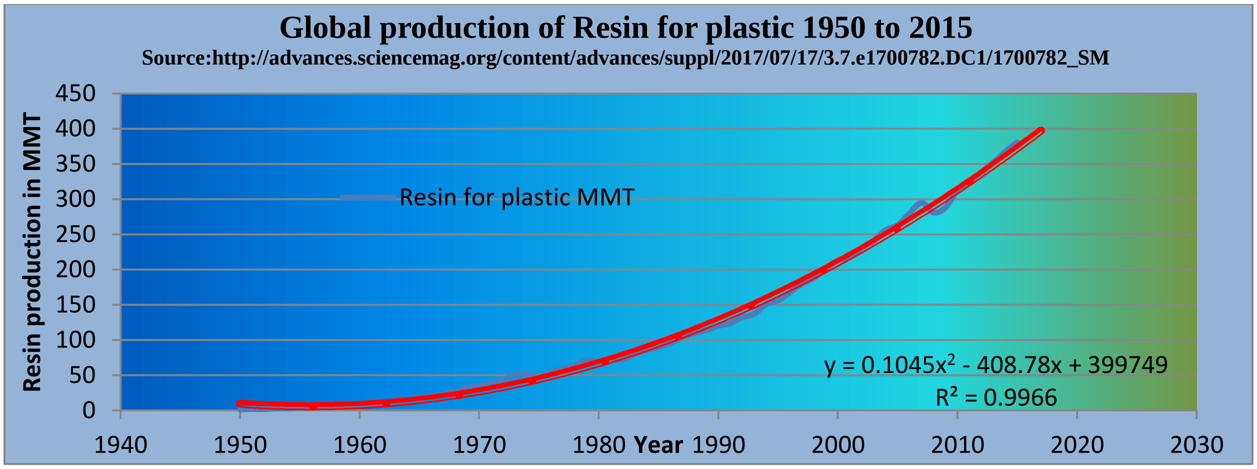

Fig 10:-Global production of Resin for plastic from 1950 to 2015,

India generated about 6300 MT of plastic as waste in 2015, from which, recycled (9%), incinerated (12%), and balance 79% was accrued in landfills. If the present trend persists, about 12,000 BMT of plastic waste shall be dumped in landfills by 2050. The Anthropocene has produced about 9 BMT of plastic whose major part is lying in our landfills and oceans and projected to rise to 33 BMT by 2050 (Geyer et al., 2017). The share of plastic industry in consumption of fossil fuels during production is about 4%. **(Fig 9).**

Global consumption of plastic was 260 MMT in 2005 but as per the report of Global Industry Analysts, 2012, it had reached the level of 381 MMT by the end of 2015 (http://coastalcare.org/2009/11 /plastic -pollution/). About 297.5 MT of plastic trash have been dumped in the ocean with an annual dumping rate of about 8 MMT/year (**Fig 11**). Besides, the plastic waste reprocessing market is growing as a perspective in the future horizon. If plastic wastes are not be handled properly, it shall invite apocalyptic situation to geosphere, Corcoran et al., 2017.

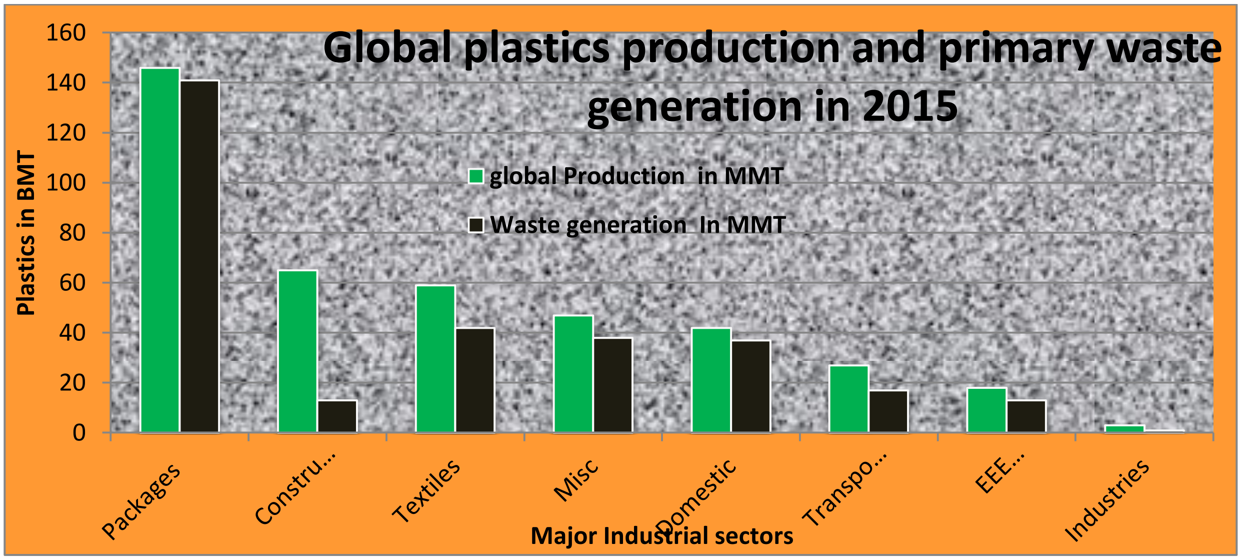

Fig 11:-Global plastics production and primary waste generation in 2015 (Source: https:// committee.iso.org/files/live/sites/

Status of plastics in India:-

The compound annual growth rate of production of plastics in India was @10% in the year 2015 with the amount of 13.4 MMT/year from 8.3MMT/year in 2010. A study conducted by FICCI estimate that the CAGR rise shall be @10.5% and the annual production rate shall be 22MMT/year by the year 2020. Financially it was INR 3.5 billion in the year 2005 which has raised to INR 10.00 billion in the year 2015 with a current per capita consumption of 11kg/per year.

Liquid waste:-

Liquids that are perilous or detrimental to health or the environment are labeled as liquid waste. Nonmetals, metals and heavy metals cannot be easily biodegraded and retained in soil/water for long period. Liquids containing Cu, Ni, Hg, Pb, As, Zn, Fe, AS, F, and Mn are either carcinogenic or harmful to human and animal health. Increased N, P, and K concentrate added from agricultural activities, toxic mineral effluents from industrial front usages are also adding to the growing lists of potential liquid waste in the Anthropocene epoch. Long-term contacts and exposure to Cu and Zn cause neurological disorders like Alzheimer diseases, muscular dystrophy, allergic reactions and genetic mutation by industrial effluents. The leachates, effluents of oil refineries, paper mills and distilleries are rich in hydrocarbon, increases BOD conc. when disposed on soil/water, develop anaerobic conditions and affect soil quality. (**Fig 10**)

The River Ganga, the center of Indian civilization is struggling for survival under profuse organic and inorganic pollution. Sewage estimated to be @ 2900Million liters is pumped into the river between Balabhadra barrage at Rishikesh and the confluence point to bay at Uluberia. CPCB has monitored the water quality (WQ) of Ganges at Rishikesh, Haridwar, Garhmukteshwar, Kannauj, Kanpur, Allahabad, Varanasi, Patna, Palta and Uluberia in 2017. It was observed that the DO level has reduced from 10mg/l in 1986 to 8.1mg/l in 2017 at Rishikesh after implementation of National Mission for Clean Ganga (NMCG) (Hindustan times 4th Feb. 2018)

Gaseous Waste:-

India is ranked as 13th in the list of 20 most polluted cities in the world (WHO). Reportedly half of Delhi's 4.4 million children have permanent lungs damage without any chances of full recovery. In 2017, State of Global Air report, published by the Health Effects Institute, states that India's report of death was of about 14.7 people per 1,00,000 population due to oxygen-related illness whereas the death rate was 5.9 people per 1,00,000 population in China. Benzene, 1-3 Butadiene and acrolein evolved from wastes are known to cause malignancy over long exposure. Acrolein has harmful effects on the eyes, skin, upper respiratory tract, and heart, even for short periods of exposure and at low concentration. Anthropogenic wastes generate CH_4 (a major GHG gas) is accumulating in the atmosphere causing an increase in global mean SAT and SST, resulting in MSL rise and climate changes. The human race would be facing the inevitable result like, deforestation, desertification, low crop yields, and scarcity of safe water. This could irreversibly damage the fragile health of the flora and fauna and bring the existing ecosystems to the verge of extinction.

Leachate composition of the landfill:-

Leachate is the Landfill aqueous material that can be biodegradable or non-biodegradable, soluble or insoluble, organic or inorganic, liquid or solid and toxic or nontoxic. The parameters are pH, temperature, BOD, COD, DO, the degree of decomposition, moisture content, climate, and landfill age.

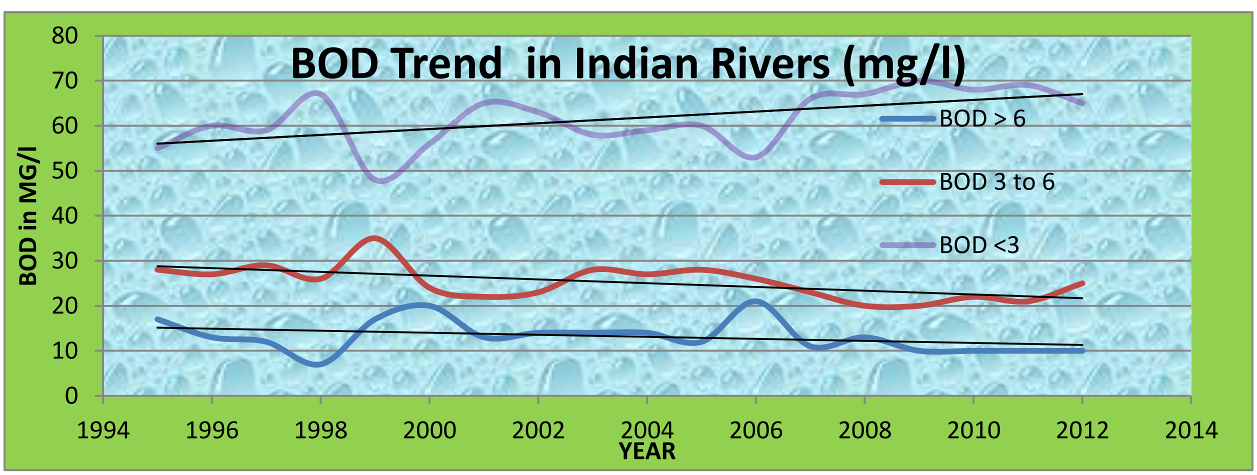

Fig 12:-Trend in WQ (BOD) of rivers in India (1995-2012) Source: NWMP, CWC India**.**

The groundwater characteristics depend upon soil and the parameters of soil to be considered are pH, permeability, infiltrative capacity, and geological stratum with mineralogy, the concentration, and toxicity of contaminants, the direction of GW flow and the depth of GWT. The Mavallipura Landfill in Bengaluru, there is leachate migration to the soil and UGW as it poses high conc. of organic and inorganic constituents, heavy metals which pose threat to the environment and health Sivapullaiah P. V., 2016.

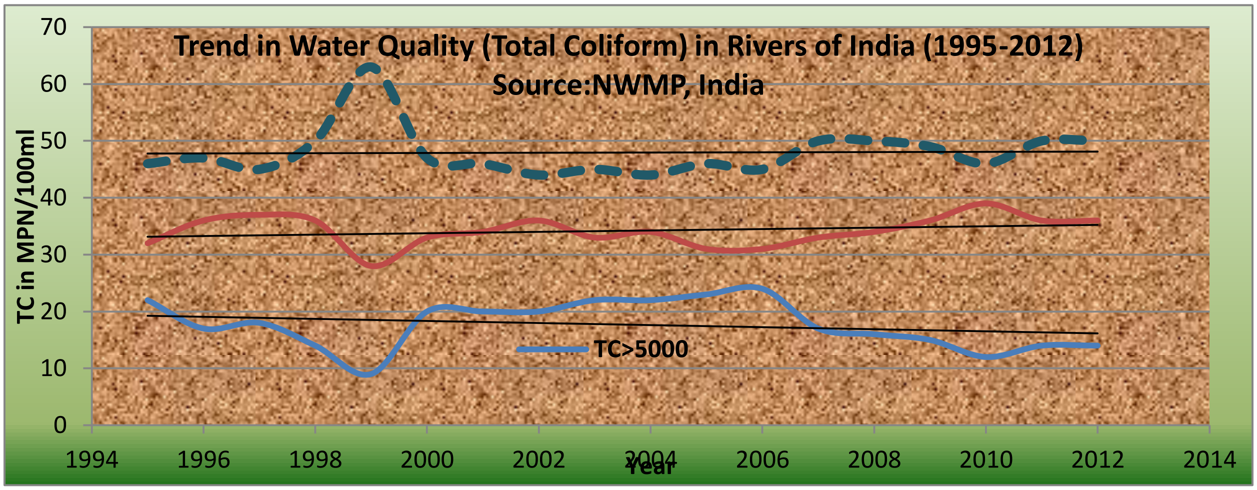

Fig 13:-Trend in WQ (Total Coliform) in Rivers of India (1995-2012) Source: NWMP, India

According to MOEF, the permissible value of Water Quality (WQ) parameters like pH, BOD, and facial coliform (FC) values should be 6.5-8.5, <3 mg/l and 500 MPN/100 ml (desirable)2500 MPN/100 ml (Maximum permissible) respectively**(Fig 12)**.The liquid waste is unsuitable for disposal to any class of landfill as the volume leachate pollute groundwater table (GWT). The high concentration of metal ions or/and hazardous organic chemicals in leachate may pollute/foul ground or/and surface water which demands proper treatment or safe disposal.

Sugar mill effluents from industries have high suspended solids (SS), dissolved solids (DS), BOD, COD, chloride, Ca, and Mg. Sonipat area in Haryana has become almost barren due to industrial effluents and exploiting groundwater for excess irrigation **(Fig 12).** National Water Quality Monitoring Programme (NWMP) on analysis of water bodies from rivers drains and landfill leachates reported that the trend in chemical parameters is in a gradual declining trend. CPCB monitored the water quality of 870 observatories in 26 States and 5 UT's of India. The status of a trend in BOD **(Fig 12),** & Total Coliform (TC) (**Fig 13)** and Faecal Coliform (FC) **(Fig 14)** for the period 1995-2012 has exhibited an improving trend.

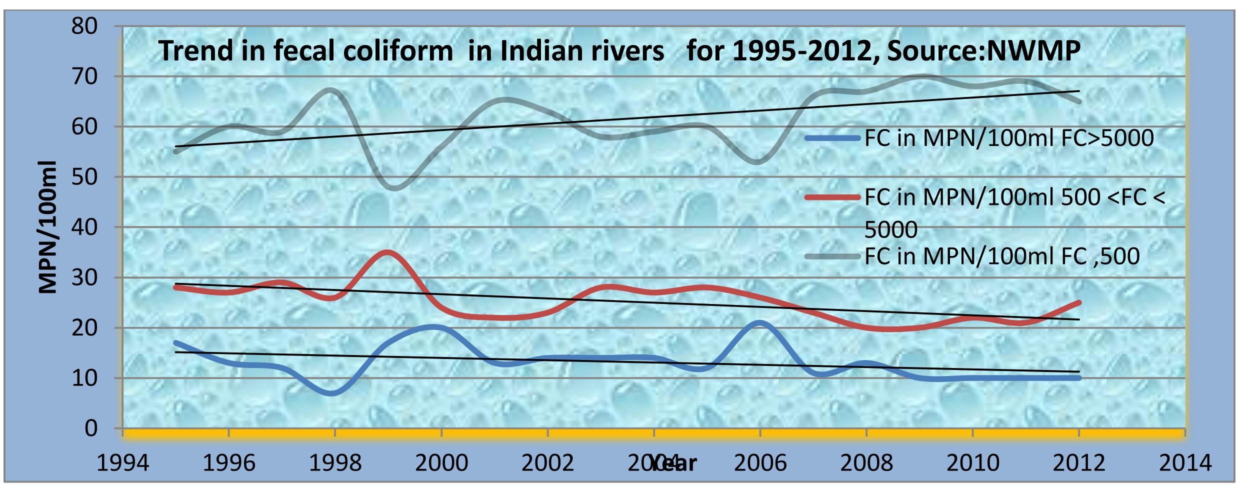

Fig 14:-Trend in fecal coliform in Indian rivers (1995-2012), Source: NWMP (India. Gov. in)

The results show that the BOD is increasing continuously from 2006 to 2012 onwards despite self-cleansing capacity of rivers and streams were continuously polluted from 2006 to 2012 onwards. The FC and TC values were showing an average falling trend which indicates depletion of organic parameters in water from 1995-2012. The gradual rise in water quality (WQ) parameters with regard to organic pollution is decreasing in major rivers of India (**Fig 15**).

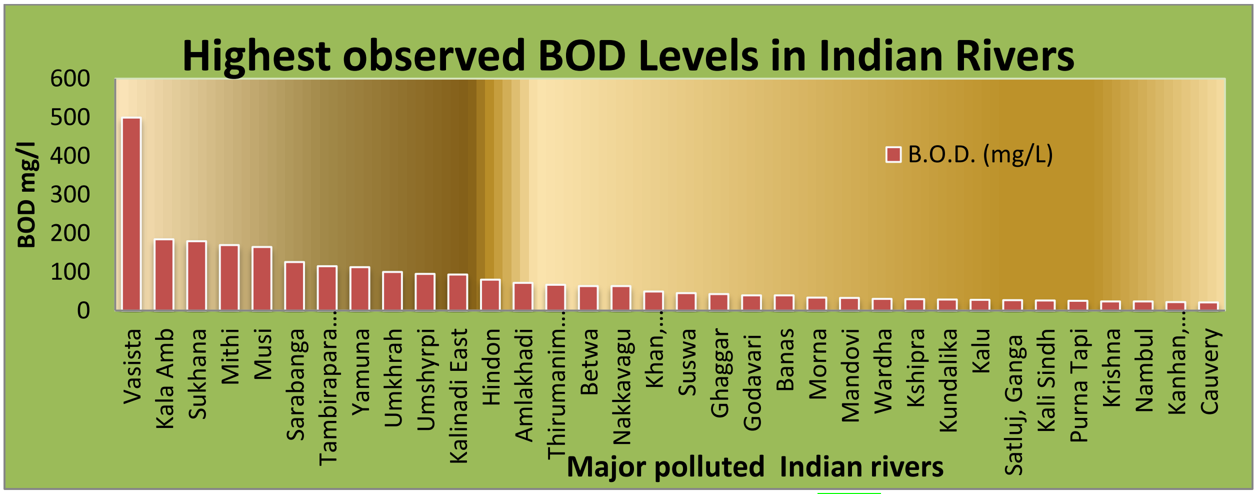

Fig 15:-The most polluted rivers of India considering BOD in mg/lit(Data NWMP, India)

The analysis of the leachate water near Pune landfill showed abnormally excess Ne and Fe concentration @ 2612 to 24700 mg/lit and @ 6.6 to 8 mg/lit respectively The surrounding GWT is also infected with Na and Fe @ 918 to 2470 mg/lit and 6.5 to 9.3 mg/lit in nearby well water Mane et. al.,2015. Hazardous liquid wastes can be moderated by ignitability, reactivity, corrosivity, toxicity but to be handled carefully (EPA, 2005).

In some areas of Punjab, groundwater has been contaminated by Hg and Pb to such an extent that use of water for drinking purposes has caused mutation in DNA. It is also reported that the increased incidence of cancer in the population due to over-exploitation of groundwater. The tannery water in Tamil Nadu had heavily polluted the quality of surface and groundwater making it unfit for drinking and agriculture. Effluents of Zn smelter near Udaipur, Rajasthan, contained the high level of Zn than the permissible limit. The quality of drinking water has already deteriorated at present in some areas; due to the release of toxic chemicals like Styrene Trimer, and Bisphenol A. The reproductive system is affected by Bisphenol A (an endocrine disruptor) which endangers the aqua habitats and human. It interferes with the basic food chain, pollutes soil, air, and groundwater. After contamination, it starts wiping out the flora, fauna, and aqua habitats inclusive human with high social and economic cost to decontaminate the affected areas. **Fig 16.**

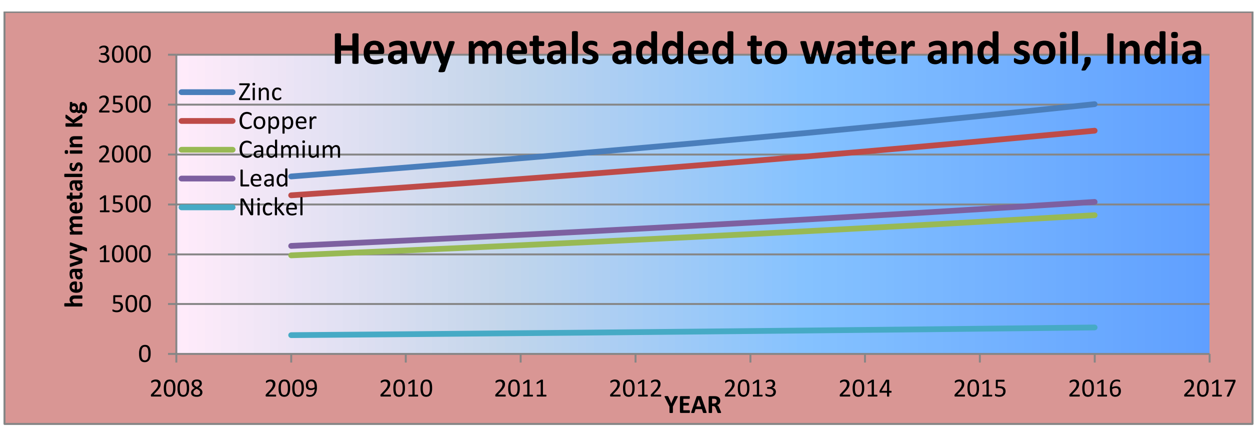

Fig 16:-Different types of heavy metals added to landfill and the groundwater

Nuclear Waste:-
Isotopes are common in nature, ^{14}C, and a naturally rare isotope, ^{293}Pu, are present through the Earth's mid-latitudes due to nuclear testing in the 1950s onward Vaughan Adam 2018. Nuclear Power Plants provide ≈20% of world's electricity (8% in the U.S.). Nuclear waste is the byproduct or end product from radioactivity. Nuclear waste is generated throughout the fuel cycle. The front end waste as LLW (low-level α-emission waste, 1mCi - 10 mCi), Service period waste as ILW (10mCi – 10 Ci),) contaminate the reactor housings and wastewater. Backend waste (HLW) is highly emissive containing fuel rods and reactor cores which is > 10 Ci.

India generates 4020 MW electricity from nuclear resources in 2016 and projected to reach the level of 20,000 MW by 2020. On an average, a 1000 MW Nuclear Power Plant generates 25 MT of N-waste (spent fuel/ year), Upon reuse and reprocessing the final residue generated is about 700 kg of high-level waste/ year (HLW) which must be environmentally isolated and to be stored for long (vitrification). About 4.8 MT of nuclear waste is generated and stored in steel canisters for minimum 50 years as the nuclear wastes are highly radioactive and emitting both γ and β particles such as Ur-234, Ne-237, Pl-238 and Am-241 *etc.*. The amount of such waste generated in India is around 4MT/GW/year.

Filtration, ion exchange, evaporation, incineration, compaction, and solidification are the common methods of disposal of nuclear waste. Permanent nuclear disposal can be undertaken by geological repositories, deep boreholes, separation and transmutation and in space. Nuclear waste disposal in the deep sea has been restricted legally through international treaties. Nuclear landfills (Yucca Mountain, Nevada in US 1999) are situated at a far distance from nuclear plants and wastes are buried at a deep depth below ground (about >500m)

Nano wastes:-
Three types of Nanomaterials (Nano-particles, Nano-plates or Nano-fibers) are gifts of the Anthropocene epoch whose dimensions lie between 1 to100 nm. About 2,68,000MT Engineering Nanomaterials (ENM) had been produced in 2010 and continuously increasing @ ≈ 25% annually **Bozena M., (2016**). Nano-wastes are created from the by-product during manufacture of ENM. Wastes of ENM are available in the body or on surfaces of different solids, liquids (suspension) and in the air within containers

Silver ornaments are popular since long for its anti-bacterial properties but its nano silver particles are hostile towards bacteria which can kill cells in human body and also beneficial microbes in soil even at low concentration Nanoparticles of titanium dioxide (TiO_2) utilized in the manufacture of cosmetics, sunscreens, paint, and vitamins are also carcinogenic. Nano-technology is gaining extensive importance in multifarious uses of the new technology. But clear standards and regulations towards use, disposal, and recycling of Nano-wastes are not in place at present. Present generation needs to work out measures to deal with its toxicity and environmental impact. The exponential growth of ENM waste and its failure to deal with same pose great challenge to the Anthropocene.

E-Wastes:-
Basel Action Network (BAN) has estimated that ≈500 million computers are in use throughout the globe containing 2.870 MMT of plastics, 0.717 MMT of lead and 0.287 MMT of Hg. On disposal of e-waste, the lead is added into the soil and the groundwater. If the tube is crushed and burned, it emits toxic fumes into the air which is very harmful to human health and environment, Ramachandran et. al. 2004. The globe is saddled with a generation of an estimated amount of 44.7 MMT of e-waste in 2016 whereas India's contribution was 2MMT. African continent receives about 50% of e-waste from other continents, especially from developed and advanced nations. ~~a~~ China generates 160 MMT/year e-devices. It is alarming that hazardous e-waste is huge and their reuse is limited at present. It is high time to address redressal of the problem of e-waste of the globe. For example, some e-waste is shipped from advanced nations and dumped in the backyard of Acra Ghana and the kids burning the scrap in junkyards of Acra are oblivious of the ferocity and toxicity of their activity.

Electronic products became popular in India from 1980 onwards. India is the 5th biggest consumer of electronics goods (1.7 MMT in 2014) of the world. E-goods purchased by consumers during 1980's are in the process of discarding old, outdated and bulky electronic/electrical gadgets. CR- Tube televisions sets are being replaced by replacing with LCD or Plasma monitors. As per a study by ASSOCHAM, India, the CAGR [Compound Annual Growth Rate] of e-wastes in India is 30% of the production amount. UN has estimated, about 90% of the world's e-waste is illegally traded or dumped annually and finally after few days it become a part to the landfill. Per capita e-waste rate in India is very less in comparison to other developing nations due to its huge demography as the majority of the population are under low-income group. New Moti Bagh, New Delhi has adopted a 'zero e-waste' project at the 'General Pool Residential Accommodation Complex (GPRA). BBMP, Bengaluru has adopted segregation of wastes by adopting a collection of wet, dry, and e-waste, a three-bin system. The e-wastes are to be specially recycled as per norms. MAIT (Manufacturers Association for Information Technology) has reported that a small state Odisha, e-waste generation is projected to rise from 71 MT by 2021 to 1236.50 MT to 2050.

The Indian states generating e-waste in decreasing order are Maharashtra, TN, AP, Delhi, Karnataka, Gujarat, and UP. The e-waste Management and Handling Rules, 2011, which governs that India has to command over the e-users health and the environment. The e-waste management system is regulating issues related to disposal, import and recycling of e-waste and is applicable to factories, producer, consumer or bulk consumer. However, the hazardous e-waste must not be mixed with MSW and not to be disposed in landfills. Repairs and refurbishment of electronics items and its reuse at low cost are the best solutions to take the benefits of technology which promote recycling.

Industrial waste:-

Human has passed through four industrial revolutions. The first was in 1850, where coal and iron were the major materials for use. Slag, fly ash and CO_2 were the major wastes. The 2nd industrial revolution was during the mid-20th century which was based upon cost reduction and mass production where wastes from industries and power plants are the major wastes. During the late 20th century, the third industrial revolution brought widespread use of fossil fuels alongwith advanced electronics equipment and automatic gadgets. The scientifically advanced equipment's generated huge volume e-wastes whose disposal pose serious challenges for the mankind. The development in computer and Nanotechnology has invited the fourth industrial revolution and nanotechnology. Concrete, plastics, and aluminum composites are the most used man-made material which is produced @ of around 500MMT, 50 BMT and 500 MMT a year. Sediments containing any of nano and e-wastes materials will be a clear sign of the Anthropocene

Industrial wastes can be hazardous or non-hazardous and the hazardous wastes are either heavy metals or hydrocarbons. Other hazardous wastes are end products of explosives, compressed gasses, flammable liquids, oxidizers, poisonous/toxic materials, and corrosives which are found in landfills and handled by rag pickers. The heavy metals can be traced in geosphere such as As (in mines area), Cd (from mining, waste from fertilizer industry, waste batteries), Cr (mining and leather industries), Pb (batteries and e-factories), Mn (mining), Hg (medicine or chloro-alkali industries), and Ni (mining or metal plating industries), Organic wastes perilous to human and animals are benzene (Petrochemical refineries), and some dioxins. Unplanned and unorganized industrial establishments, obsolete small-scale industries (SSI's) lacking funds are not giving due importance to bio-degradable products, wastes, dumps and landfill leachate. To the certain extent, government policies with regard to use scarce resources like land and water have added to the increasing pollution level to rivers, water bodies and environment.

To produce 1 Kg of steel 2.6 to 2.8 Kg of Hematite ore is needed. About 30-35 MMT of iron and steel slag/sludge is generated and dumped in and around the steel plant areas annually in India, Amit Kumar (2014). Industrial solid wastes from industries are slag, sludge, dust, mill scale, fluxes, scrap, muck, debris whereas the industrial liquid wastes are oil, greases, and factory effluents, and the gaseous wastes are CO_2, toxic gases, smog, fumes and flue gasses. Aluminum is extracted from bauxites is ≈ 234 (MMT) and generate end waste red mud (RM) of 9×10^7MT across the globe. with India accounting for 19.3 MMT and RM of 2×10^6 MT respectively Mishra et al, 2014.

Globally cement industries are growing @8%, Sharma K (2013) supplementing 5% of the kiln gasses to the atmosphere Metz (2007). CPCB has reported that wastes from 132 numbers of cement industries with installed capacity 166 MTPA are the most polluting industries in India ~~as~~ contributing to the level of the hazardous cement dust contains like nickel, cobalt, lead, and chromium. This massive volume of wastes has adverse impact on vegetation, human and animal health and ecosystems.

Biomedical wastes:-

The biomedical wastes whether solid or liquid are disposed directly in drains at present and these Biomedical (BM) wastes are sources for nosocomial infections. BM wastes from hospitals, research centers, labs, and mortuaries are contaminating air, soil, and water due to lack of infection of control practices and poor waste management system. The persons handling such BW like rag pickers, sanitation workers, non-medical staff, waste handlers are directly exposed to the hazards of BW. It is estimated that a lady can generate up to 125 kg of sanitary waste during her menstruating years and with a child generating 25-30kg/year. Sanitary pads/napkin/hoggish takes around 500 to 800 years to degrade as these are made of materials like bleached wood pulp, LDPE plastic polymers and super-absorbent (polyacrylate), https://www.smithsonianmag. com/smart -news/humans-180964125.. It is assessed that the developed countries produce @1.5Kg/bed/day BM wastes whereas in India the average rate of production is 1.2Kg/bed/day. The biomedical waste generated in India was 507.6MT. Out of which 80% was nonhazardous, 1% radioactive, genotoxic and cytotoxic, 1% sharp, 3% pharmaceuticals and chemicals, 5% hazardous but not infectious and rest10% were pathogenic and infectious. The 40-50% BM wastes are discharged to drains or dumped in open space without proper and scientific treatment. The viruses, parasites and bacteria's from BM wastes can cause gastroenteric, respiratory, ocular, meningitis, bloodborne diseases and many others ailments and the present generation is facing the inevitable consequences.

Marine Waste:-

During the Great Acceleration, the atmospheric CO2 concentration grew, from 311 ppm in 1950 to 369 ppm in 2000 (W. Steffen et al., 2011).and 415ppm in 2015. About one-third of the carbon dioxide released by anthropogenic activity is absorbed by the oceans. When CO_2 is dissolved in seawater, it produces carbonic acid. The carbonic acid dissociates the water releasing hydrogen ions and bicarbonate. Then, the formation of bicarbonate removes carbonate ions from the water, making them less available for use by the marine organisms. ocean acidification affects the biogeochemical dynamics of calcium carbonate, organic carbon, nitrogen, and phosphorus in the ocean. The result is having a direct impact on marine habitats that build shells from calcium carbonate, like planktonic coccolithophores, mollusks, echinoderms, corals, and coralline algae. Globally ocean trash dumped to sea amounts to 269,000 MT floating as wastes (5.25 trillion pieces of plastics/four billion plastic microfibers per square kilometer litter) Parker Laura, 2015[20]. The study of other wastes such as oils, grease, containers, storm trashes, and metallic wastes are under investigation

Man mediated minerals:-

Plastiglomerate, an Anthropocene mineral was found on Kamilo Beach Hawaii. There are 208 manmade mediated minerals are in the present epoch. Their impact on the environment and human health are under study. International Mineralogical Association (IMA) has identified about 5200 types of minerals in nature. But the manmade minerals are 208 number included in the 20th century to date. During the periods of great oxidation (≈2BYMP) when O_2 was started producing by photosynthetic bacteria in Earth's atmosphere. The minerals estimated were only 4000 in number in past and new minerals were mostly oxides of iron, and new minerals like aluminum and manganese added later. (American Mineralogy, DOI: 10. 2138/am-2017-5875). Anthropogenic activities have widely affected the distribution of minerals across the globe to change the stratigraphic record. The synthetic mineral like YAG crystals for lasers; Portland cement have indirectly remediated and discovered in tunnel wall of mines. The other forms of manmade minerals generated from wastes are by weathering of mine dumps and slag, landfills. Examples of such remediated minerals are plastiglomerate, blue-lizardite, fluckite or kokinosite, Simonkolleite [Zn5(OH)8Cl2·H2O], https://www.reuters.com/ article /us-environment-Anthropocene-idUSKBN1685E4. Some manmade minerals and alloys are bronze in Egypt, tin in Canada, and lead Tunisia formed before the Anthropocene. The redistribution of Earth's frustum minerals and the mining/industrial dumps have an adverse impact on human and animal health and the biome. There is an immediate need to monitor these negative impacts and develop ways and means to address these sensitive issues

Change in Geology, lithology, and limnology:-

With burgeoning population growth and modernization, humans have un-earthen about 50% of the subterranean land face in the Anthropocene epoch for their use. Settlement, farming, mining, deforestation, damming, and coastal reclamation have produced huge quantities of wastes and provided the frustum with a new cover. The never-ending appetite of the human race for modernization and industrialization has altered the natural landscape of geology, lithology, and limnology.

The federal actions to manage waste in India:-

The regulatory regime to manage waste in India was initiated by MOEF, GOI in 1986 to protect the environment as Environment Protection Act, 1986 ("EPA") with the imposition of the penalty to the law deviator (up to 5 years and/or fine up to INR 100,000). Further, GOI made a statutory law for environment impact assessment where redressal of its impact was considered for both new and old establishments. A number of rules and notifications were issued to manage wastes from different sectors. EIA notification 1986, 1994, 1996 and revision 2006 and 2009 are few examples. Considering the quantity and hazardousness of e-wastes, The Municipal Solid Waste (Management & Handling) Rules, 2000,The Hazardous Waste (Management & Handling) Rules, 1989, Biomedical Waste (Management and Handling) Rules, 1998, Manufacture, Storage and Import of Hazardous Chemicals rules, 1989, The Batteries (Management and Handling) Rules, 2001, The Hazardous Wastes (Management, Handling, Transboundary Movement) Rules, 2008, Electronic Waste (Management and Handling) Rules, 2011, The Plastic Waste (Management and Handling) Rules, 2011, E-Waste Management Rules, 2016 and Solid Waste Management Rules 2016 were framed and introduced in India.

Major national level schemes in vogue to manage wastes in India are Central Rural Sanitation Programme (1986), Total Sanitation Campaign (1999), Nirmal Bharat Abhiyan (2012): Swachh Bharat Mission (Gramin) (2014). The Swachh Bharat Mission - Gramin, Ministry of Drinking Water and Sanitation have promised an end to open defecation by 2019. Based on available official records the achievement is significant as on 24.06.2018. It is reported that Ward wise door to door Waste Collection in municipalities achieved are 51734 wards, Waste converted to energy @88.4 MW (power production) and Waste to Compost in 2016, was 1,64,891.6MT in India

Discussion:-

Wastes in the Anthropocene epoch are mostly non-degradable, durable, toxic and pervasive with resilient stratagems of diffusion and contamination. Time is the best decomposer of the wastes and rivers possess their own self-cleaning properties. But wastes in Anthropocene don't degrade or take a large period for mutation. Unscientific and improper management of waste adversely affects the health of human and animals leading to huge social and economic costs. The collateral damage to vegetation, flora, fauna, ground waters, aquatic, marine and glacial resources and ultimately climate is increasingly realized by the human race.

India in particular needs immediate workable, sustainable, collaborative efficient and effective framework for reducing hazardous wastes in the present great acceleration periods of the Anthropocene epoch. To avert any epidemic chaos and to construct smart cities both economically and healthy, it is urgent to have a well-defined participatory waste management strategies. The broad procedure of reducing waste are a generation, minimization, recycling, collection, treatment, disposal by considering the economics of disposal procedure including framing policy decisions at state and national level on urgent basis.

Managing Solid waste, the steps followed are resource recovery, composting, vermin composting, energy recovery, incineration, pyrolysis, gasification and anaerobic digestion. The actions in the waste disposal process including huge construction wastes comprises of training/awareness, creation and maintaining a supply chain of wastes, generation/collection/ economy in transportation, recycling, energy generation and marketing with a strong monitoring system including GPS monitoring., The huge gap existing between collection and treatment at present by urban bodies in India should be addressed.

For effective and economic management of waste in the Anthropocene epoch are waste reduction and segregation for recycling and reuse at the source. The collection should be prompt, efficient laying emphasis on the sound disposal by implementing the smart and green concept, maintaining cleanliness by joining hands together.

Do and do not's in Micro-Waste Engineering:

Subject	**Do's**	**Do Not's**
Cleanliness	Should start at hands in operation	Don't throw garbage/wastes strewn and never in drains & water bodies
Greenness	Maintain nearby green by plantation	Discourage deforestation
Segregation	segregate waste *Bio-degradable, Dry Waste* (plastic, paper, metal, wood, & *Domestic Hazardous Waste* like plastics, diapers, sanitary napkins, mosquito repellent, soaps	Don't mix nuclear, garbage, e-wastes, biomedical and chemicals, liquid wastes. Dispose of all individually after segregation.
Littering	One house, one latrine at least say no to open defecation	Don't litter and don't let others litter
Defecation	One house at least one latreen and one compost pit	Don't defecate and urinate in open area.
Redesign	Use products causing less waste	Don't stress on volume but on use
Cut short	Use of early decomposable materials making less waste, i.e papers, cloths packets etc.	Don't use non-disposables materials like polymers, building materials

Packaging	Redesign packaging and implement packaging return schedule for reuse	don't purchase piecemeal, Switch to reusable transport containers
Storing	Store reusable for rebuilding or recovery like planks, bricks, cement blocks, slabs and containers	Don't hide other workers and the authorities. Fence the area, or secure the waste in labeled cans.
Reuse	Reuse office furniture, fixtures, and supplies, incoming to outgoing of packaging materials	Don't reuse hazardous & nuclear wastes or e-wastes in a landfill.,
Donate/Exchange	old books, old clothes, old computers, excess building materials, old equipment	Don't use Septic System as a garbage can
Recycling	Reusable and recyclable wastes are to separated and either donated or reused.	Fused CFL's, LCD's or tube lights are not to be wasted and recycled to recover Hg, P, and glass
Disposals	Dispose of chemicals, burnt oils and toxic fuels at approved waste sites. Dispose of solid wastes in landfills. Set own bio-methanation. system.	Don't pour gasoline, thinners, paint, oil, solvents, insecticides, in the drain. don't poison your septic system
Biomedical wastes	Clean hospitals with in-house segregation clean and with BM waste disposal unit with each medical unit, research centers, and slaughterhouses	Don't mix wastes from hospitals and clinics with other wastes. Store them in sealed, labeled containers
Transportation	The vehicles may be fully utilized at least two shifts to lift containers.	Don't have manual loading or replaced to direct lifting containers by hydraulic or non-hydraulic devices or direct loading from the door
Bioreactor landfills	Municipality/N.A.C/institution wise must maintain Bioreactor landfill	Don't decompose/dump the toxic gas generating garbage/waste
Training	Conduct ongoing training classes to dispose of wastes of the unit/industry. Periodical checking of waste management by senior management.	Do not allow the trash vendors, rag pickers to the landfill and dump yards. Train them about the health impact of wastes.
Governance	Refer regulatory body if no waste disposal scheme. Efficient use of existing waste management facilities and landfills.	Don't dump wastes near water body /drains/ ecologically subtle area like the zoo, parks, forest or beach.
Reporting	The waste generation must be reported regularly and correctly.	Don't hide hazardous BM waste, e-waste, and nuclear waste.
Penalty	Inspect and investigate the lawbreaker in waste disposal and impose heavy penalties and imprisonment.	Don't be lenient with the person/institutions considering vagaries in waste management

Conclusion:-

The Anthropocene epoch (the age of human) can also be designated as the age of wastes. The scientific management of waste comprises segregation, collection, storage, transportation, disposal, and reporting. If waste is transported to a destination for contaminant disposal or destruction, reporting is mandatory. Containment destinations include landfill, tailings (waste ponds), storage facilities, and underground injection or other long-term purpose-built waste storage structure by reducing, reuse, recycle and rebuy C&D materials. It also includes the transport or movement of substances contained in waste to a sewerage system. Reporting must be voluntary if transfers are to a destination for reuse, recycling, reprocessing, purification, partial purification, immobilization, remediation or energy recovery. The final fate of Wastes, which can be recyclable even, ends in dumps and landfills. The most efficient waste management stresses upon efficient segregation, energy restoration and resources recovery.

References:-

1. Joshi, R., & Ahmed, S. 2016, Status and challenges of municipal solid waste management in India: A review. Cogent Environmental Science, 2(1), 1139434, https://doi.org/10. 1080/23311843.2016.1139434
2. Lahiri Samir, 2017, India's challenges in waste management, Down to earth, http://www . downtoearth.org. in/blog/india-s-challenges-in-waste-management-56753
3. Alemayehu E., 2004, Solid and Liquid Waste Management, EPHTI, For Health Extension Workers, https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes/health_extension_trainees/ln_hew__solid_waste_final.pdf, Jimma University
4. Sharholya M., Ahmad K., Mahmooda G., Trivedi R.C., 2008, Municipal solid waste management in Indian cities – A review, Elsevier, Waste Management, Vol- 28 (2), pp- 459-467, https://doi.org/10.1016/j.wasman
5. Ghosal T., Bhatacharjya R., 2008, State Level Carbon Dioxide Emissions of India 1980 – 2001, Contemporary Issues and Ideas in Social Sciences April 2008, Bureau of Applied Economics and Statistics, Government of West Bengal, New Secretariat Buildings; `B' Block; 5th Floor 1, Kiron Sankar Roy Road, Kolkata - 700 001, West Bengal.
6. Ellis, E., 2009, Stop Trying to Save the Planet. Wired Science. (6). Available from: https://www.wired.com/ 2009/05/ftf-ellis-1/
7. Ellis, E., 2011, The age of Anthropocene, should we worry?, Neither Good nor Bad. New York Times. Available from: https://www.nytimes.com/ room fordebate/2011/05/19/the-age-of-anthropocene-should-we-worry/neither-good-nor-bad
8. Ellis, E.C, 2012, The Planet of no Return. Human Resilience on an Artificial Earth. Breakthrough Jr., https://thebreak through. org/index. php/journal /past-issues/issue-2/the-planet-of-no-return
9. Paul Randell, 2012, Liquid waste assessment, Assessment Final Report No AA004173-R01-06, Hyder Consulting Pty Ltd (ABN 76 104 485 289)Department of Sustainability, Environment, Water, Population and Communities,(DSEWPaC) , Australia.
10. Annepu R. K., 2012, Sustainable Solid Waste Management in India, Waste-to-Energy, Thesis Columbia University, Research and Technology Council (WTERT),
11. Raghab S. M., M. Abd, Meguid A. El, Hegazi H. A., 2013, Treatment of leachate from municipal solid waste landfill, Housing and Building National Research Center, HBRC journal, Vol-13, PP-187-192, https://doi.org/10.1016/j.hbrcj.2013.05.007
12. Crutzen, P.J. & Steffen, W., 2003, How Long Have We Been in the Anthropocene Era? Climatic Change. Vol. 61(3), pp. 251-257.
13. Crutzen, P.J. & Schwägerl, C., 2011, Living in the Anthropocene: Toward a New Global Ethos. Yale Environment 360. Available from: http://e360.yale.edu/features/living_in_ the_ anthropocene_toward _a_new_global_ethos
14. Zalasiewicz, J., Colin N. Waters , Mark Williams, Barnosky A. D., Cearreta A., Crutzen Paul , Erle Ellis, Ellis M. A. et. al., 2014, When did the Anthropocene begin? A mid-twentieth century.
15. Madaan Neha, 2015, Maharashtra tops in solid waste generation, TNN, Apr 4, 2015, Times of India.
16. Agarwal R., Chaudhary M., Singh J., 2015, Waste management initiatives in India for human wellbeing, European Scientific Journal, June 2015 /SPECIAL/ edition ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431
17. Singh SK, Anunay G, Rohit G, Shivangi G, Vipul V., 2016, Greenhouse Gas Emissions from Landfills: A Case of NCT of Delhi, India. J Climatol Weather Forecasting 4:157. doi:10.4172/2332-2594.1000157
18. Yadav I. C. and Devi N. L., 2016, Municipal Solid Waste Management in Imphal Town, Northeast India: A Critical Analysis of Existing Management Practices and Proposed Action Plans, International Journal of Waste Resources, Vol. 6(3), pp. 1-8 DOI: 10.41 72/2252-5211.1000238
19. Choudhury M., Dutta J, 2017, A Comparative Study of Municipal Solid Waste Management Status for Three Major Towns of Upper Assam-India. Int J Waste Resour 7: 291. doi: 10.4172/2252-5211.1000291.
20. Parker L., 2017, A Whopping 91% of Plastic Isn't Recycled, , https://news.national geographic .com/2017/07/plastic-produced-recycling-waste-ocean-trash-debris-environment / National geographics July 19, 2017
21. Song K, Wen Z, Xu Y., Yang H., Lyu L., Zhao Y., Fang C., Shang Y., Du J., 2018, Dissolved carbon in a large variety of lakes across five limnetic regions in China, Elsevier, Jr. of hydrology, Vol 563, Pp. 143-154
22. Mishra S. P., 2017, The apocalyptic Anthropocene epoch and its management in India, Int. Jour. Adv. Research, Vol, 5(3),pp. 645-663, DOI: 10.21474/IJAR01/3555
23. Brunnengräber A., Görge C., 2017, Nuclear Waste in the Anthropocene: Uncertainties and Unforeseeable Timescales in the Disposal of Nuclear Waste GAIA - Ecological Perspectives for Science and Society, Volume 26, Number 2, 2017, pp. 96-99(4), DOI: https://doi.org/10.14512/gaia.26.2.8

24. Mohanty C. R., Mishra U., Beuria P. R., 2014, Municipal solid waste management in Bhubaneswar, India – A review International Journal of Latest Trends in Engineering and Technology (IJLTET)
25. Sunil Kumar, Stephen R. S., Fowler G., Velis C., S., Jyoti Ku., Arya S., Rena, Rakesh Ku., Cheeseman C., 2018, Challenges and opportunities associated with waste manage- ment in India, The Royal Society, Vol. 1, pp. 1-11, DOI: 10.1098/rsos.160764
26. Khan D, Kumar A, Samadder S. R., 2016, Impact of socioeconomic status on municipal solid waste generation rate. Waste Manag. Vol.49, pp.15-25. doi:10.1016/j.wasman. 2016. 01.019. Epub PubMed PMID: 26831564.
27. . Gayakwad HP, Sasane N. B., 2015, Construction and Demolition Waste Management in India. International Research Jour. of Eng. and Technology (IRJET) 2(3): 712-715.
28. Manjunath R and Harish Ku., 2017, Reuse of construction and demolition waste, https://www.slideshare .net/ManjunathRamachandra7/construction-and-demolition-waste-in-india
29. Gupta B., Arora S. Ku., 2016, Municipal Solid Waste Management in Delhi,the Capital of India, International Journal of Innovative Research in Science, Engineering and Tech., Vol. 5 (4), pp. 5130-38, https://www.ijirset.com/upload/2016/april/106_Municipal.
30. Das S., , Bhattacharyya B. Kr., 2013, Municipal Solid Waste Characteristics and Management in Kolkata, India, International Journal of Emerging Technology and Advanced Engineering, Vol. 3(2), pp. 147-152
31. Sujatha P., Janardhanam P. V. S., 2012, Solid waste management in Chennai city, Indian J. Edu. Inf. Manage., Vol. 1(3), pp.115-125
32. Jani Kedar, 2015, Sustainable solid waste management for Ahmedabad, India, Partial Fulfilment of MSc Engineering Policy Analysis under Faculty of Technology Policy & Management, TU Delft , pp. 1-216
33. Das D., B. Majhi Ku., Pal S., Jash T., 2015, Estimation of land-fill gas generation from municipal solid waste in Indian Cities, 5th Int. Conf. on Advances in Energy Research, ICAER 2015, 15-17 Dec. 2015, Mumbai, India, Elsivier, Science Direct, Energy Procedia 90, pp. 50 – 56
34. World bank series, Hoornweg D.and Tata P. B, 2012, What a waste, A Global Review of Solid, Waste Management, Urban Dev. Series, Series No 5, World Bank, pp. 1-116
35. Paul K., Dutta A.&. Krishna A.P., 2014, A comprehensive study on landfill site selection for Kolkata City, India, Journal of the Air & Waste Management Association, 64:7, 846-861, DOI: 10.1080/10962247.2014.896834
36. Dhere A. M., Pawar C. B., Singh P., Paradeshi B., and Patil D. A., 2008, Municipal solid waste disposal in Pune city – An analysis of air and groundwater pollution, Current Sc., Vol 95 (6), pp. 773-777.
37. Geyer R., Jambeck J. R., and Law K. L., 2017, Production, use, and fate of all plastics ever made, Science Advances,Vol. 3 (7), DOI: 10.1126/sciadv.1700782
38. Corcoran P. L. and Jazvac K, Ballent A., 2017, Plastics and the Anthropocene, University of Western Ontario, London, ON, Canada, Elsivier, Encyclopedia of the Anthropocene, pp-1-8, http://dx.doi. org/10.1016 /B978-0-12-409548-9.10000-4
39. Sivapullaiah P. V., Naveen BP, Sitharam TG, 2016, Municipal Solid Waste Landfills Cons- truction and Management-A Few Concerns. Int J Waste Resour Vol. 6(214). doi:10.4172 /2252-5211.1000214
40. Mane T. T., Hingane H. N., 2015, Analytical study of solid waste management in Pune , Iindia, Journal of Environmental Research And Development Vol. 9 (4), pp. 1161-66.
41. Fremaux Anne, 2017, The return of nature in the Capitalocene, a critique of the ecomodernist version of the 'good Anthropocene', Doctoral Thesis 'Towards a Critical Theory of the Anthropocene and a Life-affirming Politics', Queen's University Belfast School of Politics, International Studies, and Philosophy
42. Mishra S. P., 2018, Defaunation during Great Acceleration Period of Anthropocene Epoch: India, World Applied Sciences Journal, Vol. 36(3), pp. 506-518, DOI: 10.5829/idosi.wasj.2018.
43. Vaughan Adam, updated 2018, Human impact has pushed Earth into the Anthropocene, scientists say, Guardian, @adamvaughan_uk
44. Bożena M. R., 2016, Directions and possibilities of the safe nanowaste management, Science technique, OWIEC CHEMIK 2016, Vol. 70 (10), pp. 593–596, http://www. chemikinternational.com/ wpcontent/ uploads /2016/10/CH_10_16_Mrowiec_GB.pdf
45. Ramachandra T.V., Varghese K. S., 2004, Environmentally sound options for e-wastes management, Envis Journal of Human Settlements, March 2004, PP. 3-11
46. Amit Kumar, 2014, Utilisation of Wastes from Integrated Steel Plant with Special Reference To India, International Journal of Engineering Research & Technology (IJERT), Vol. 3(1), pp. 47-52
47. Nayak S., Mishra S P., Panda S., 2017, Red Mud, the cutting edge of self-compacting concrete, INPRESSCO, International Journal of Current Engineering and Technology, Vol 7(2), pp.390 -396

48. Sharma K., Jain U and Singhal L, 2013, Treatment of waste generated from cement industry and their treatment- a review, www.civil.mrt.ac.lk/conference/ICSBE2012/SBE-12-13
49. Metz, B., Davidson, O., Bosch, P., Dave, R., Meyers, L. (eds) (2007). Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC. New York,
50. Steffen W., Persson A., Deutsch L, Zalasiewicz J., Williams M.,. Richardson K, et al., 2011,The Anthropocene: From Global Change to Planetary Stewardship, Springer, AMBIO,DOI 10.1007/s13280-011-0185-x