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Assessment of Automobile Service Stations for the Study of Wastewater Toxicity in Nagpur City, Maharashtra (India).

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Abstract: This study has been undertaken to investigate the toxicity of wastewater generated by automobile service stations in the Nagpur city. Exhausted engine oil wastewater was collected from some significant automobile service stations of Nagpur city during survey and combined homogenous wastewater was used for the toxicity testing experiments. Poly aromatic hydrocarbons (PAHs), Poly Chlorinated Biphenyls (PCBs), Heavy metals, detergents and other toxicants were tested. Poly aromatic hydrocarbons were detected in this wastewater such as Naphthalene 32µg/l, Fluorene 3.29µg/l, Phenanthrene 20.09µg/l, Anthracene 10.26µg/l, Fluoranthene 2.33µg/l, Pyrene 21.65µg/l, Benz(a) anthracene 1.69µg/l and Benzo(a)pyrene 2.05µg/l. Copper, Cobalt, Iron, Cadmium, Nickel, Zinc and Manganese were 0.279mg/l, 0.069mg/l, 26.047mg/l, 0.021mg/l, 0.04mg/l, 0.530mg/l and 1.344mg/l respectively detected. Wastewater pH was 7.45. Values of $NO3^-$, COD, Oil and Grease in this wastewater generated were reported more than permissible limit of effluent standard. Study also reveals that most of these service stations are lacking basic in frastructure facilities for vehicular washing and subsequent wastewater treatment. Only eleven service stations were found with systematic effluent treatment plants (ETPs). It is imperative to use effective technologies to reduce the water consumption, wastewater generation and to reuse the wastewater after vehicular servicing.

Keywords: Automobile service stations, Exhausted engine oil, Effluent treatment plants (ETPs).

I. INTRODUCTION

Population growth, urbanization and subsequent industrialization is dramatically changing our environment which not only polluting air but water too. Nagpur city is one of the fastest growing metro city in Vidarbha region and sub-capital of Maharashtra state in India. It is one of the greenest city of India with around eight to ten lakes, many freshwater ponds and two rivers. The Nag river is a river flowing through the city known for providing etymology for the name Nagpur. The Nag river runs through the midway of the Nagpur from west to east nearly seventeen kilometers and collects untreated wastewater of different sources including authorized and unauthorized automobile service stations from drainage of Nagpur Municipal Corporation (NMC). The wastewater generated from automobile servicing stations is highly toxic, but its indiscriminate discharge in drainage still is not taken seriously by the authorities.

Population growth is adding vehicular traffic in the city continuously and automobile service stations are too mushrooming to cater to the servicing needs of vehicles. Vehicles are essential for transportation and to cover long distance in a short time. The Nagpur had a total of 12,54,595 two wheelers and 1,31,412 four wheelers, while in rural part of Nagpur registered a total of 3,51,874 two wheelers and 24,340 four wheelers in the year 2017. This total number of registered vehicles in Nagpur raised to over 17 lakhs in the year 2019.

The servicing of vehicles generates large volumes of wastewater laden with exhausted engine oil which contains PAH, PCB, heavy metals, detergents, other toxicants and solid waste. When this wastewater is disposed without treatment it not only causes surface water pollution but also contaminates groundwater too and tends to accumulate in flora and fauna thus leading to mass kills of aquatic biota. Majority of rural people living by the side of river and lake depend largely on the fish as a source of protein rich

food and hence should be protected. Indiscriminate discharge of wastewater generated by automobile service stations is a serious issue of water pollution.

Toxicity of spent engine oil generated from workshops on juvenile Catfish, *Clarias gariepinus* has been reported (Ayoola and Akaeze, 2012). Today scanty information is available on the toxicity of wastewater generated by automobile service stations and hence detail studies on automobile service stations were undertaken. In the present study, a survey was carried out in 110 automobile service stations in Nagpur city.

II. MATERIALS AND METHODS

Data of automobile service stations was randomly collected from five different areas in and around Nagpur city. Questionnaire and survey method was used for data collection of automobile service stations from east, west, north, south and central part of Nagpur. Figure 1 shows the location map of servicing stations in Nagpur city that are plotted and pointed with Global positioning system (GPS). These automobile servicing stations were broadly classified into three main categories viz; Major, medium and minor servicing stations. Major servicing stations cater services to tractors, trolleys, buses, lorries, Volvo, tippers and trucks. Medium service stations catering services to four wheelers like cars and minor stations caters servicing to scooters, bikes and auto rickshaws. Survey of a total 110 automobile service stations in and around Nagpur city was carried out of which 11 servicing stations were major, 53 servicing stations were medium and 46 servicing stations were minor. Table 1 to 3 shows a list of automobile servicing stations in Nagpur.

Wastewater Collection: Significant automobile servicing stations were identified for wastewater collection. Photographs of each servicing station in which a ramp for washing-cleaning, outlet of station and effluent treatment plant (ETP) were taken during the survey. Wastewater was collected on hourly basis for around eight hours and composited. This combined homogenous wastewater tested as per standard methods (APHA, 2012) for physio-chemical and metal analysis. Combined wastewater was then used for further experimental work with respect to toxicity testing. Volume of water required for vehicular washing depends on the condition of the vehicle, which varies from vehicle to vehicle.

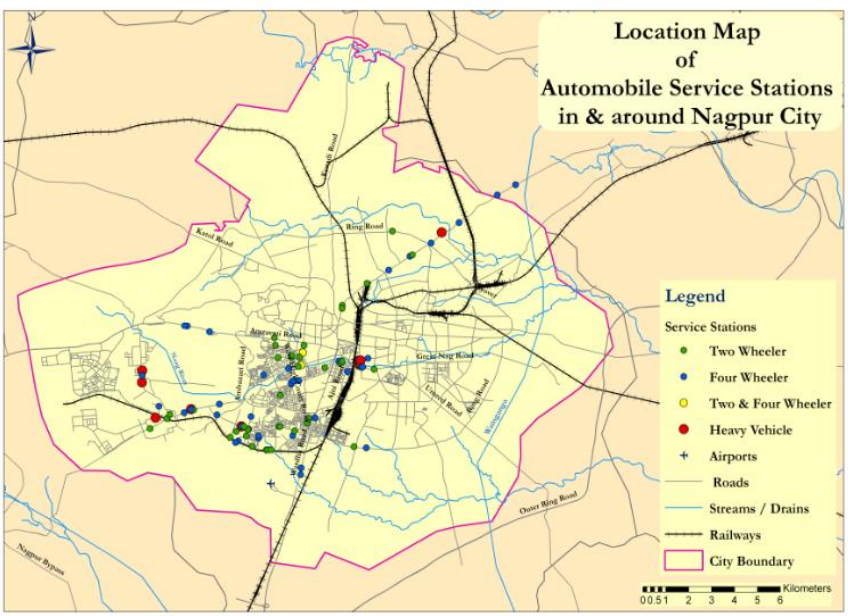

Fig 1: Location map of servicing stations in and around Nagpur city.
(Source: Developed from Survey of India Topo sheets by Sanjeev Satyanarayan)

Table 1: Automobile service stations in Nagpur city (Category: Major)

Name of Service Stations	
1] Jaika Motors-Tata Motors, Ltd., Kamthi Road.	7] Mahindra -Tracx& Bus, Surabardi, Amravati Rd.
2] JCB Anand	8] Nangia Motors/Tata Mega & Kinetic Green
3] K.S. Cranes	9] Nilawar Motors & Equipments Pvt. Ltd. Surabardi, Amravati Rd.
4] Kesar Motors, Hingna Road	10] Shri Ekvira Wheels & Service Centre, Ghat Rd.
5] M.S. State Transport Depot.	11] Volvo Service & Parts Centre, Surabardi, Amravati Rd.
6] Mahindra Tractors	

Table 2: Automobile service stations in Nagpur city (Category: Medium)

Name of Service Stations	
1] Khamla Automobiles Service Centre, Khamla sqr.	27] Maruti Suzuki -Nexa
2] M.S.Servicing Centre, Gandhi nagar, Nagpur.	28] Maruti-Suzuki Service Auto Manufacturers
3] A To Z Garage & Service Centre, Hingna road.	29] Maruti-Suzuki, Automotive Ltd, Kamthi Road.
4] Ajay Automobiles	30] Nangia Motors/Tata
5] Arun Ford	31] Navnit Cars Pvt., Ltd.,Skoda-Auto., Amravati Road.
6] Arya Cars, Bhandara Road, Nagpur.	32] New Mechano Automobile Service Centre
7] Ashish Automobiles	33] Nissan-Datsun Provincial.
8] Auto Technique, IT Park Road, Nagpur.	34] Patani Automobiles
9] Baba-Automobile Works	35] Rajlaxmi Sales & Services
10] Balaji-Motors, Hingna Road	36] Rushabh-Honda, Amravati Road, Nagpur.
11] Bhagat Automobiles, Hingna Road, Nagpur	37] Sagar-Automobiles, Wardha Road, Nagpur.
12] Boss Mechanical Works, Hingna Road.	38] Sai-Automobiles, Hingna Road.
13] Eros Hyundai, Ghat road, Nagpur	39] Sara-Automobiles, Indraprasta Nagar
14] Gunny automobile, Swalambi nagar	40] Sara-Motors, Swalambi-Nagar, Nagpur.
15] Jaydev automobile, ring road	41] Sequel Ford, Kamal chowk, Nagpur
16] Kale automobile	42] Bharat automobile, Bajaj nagar, Nagpur
17] Ketan Hyundai, Amravati road	43] Seva Automotive Pvt. Ltd., Amravati Road, Nagpur.
18] Khamla Motors / Tata Motors	44] Seva Automotive Pvt. Ltd. MIDC, Hingna Rd, Nagpur.
19] Car Sweety, 10, Shukla nagar, Nagpur.	45] Shree Autorestorers/Honda Service Station
20] D.D.Motors, Subhash nagar, Nagpur	46] Shri-Auto Service & Auto Spare Parts,.
21] Dass Welt Auto, Hingna, MIDC	47] Deep-Dizaels, Hingna Road
22] Deekay Motors, Great nag road	48] Shri Ganesh Servicing & Washing, Bajaj Nagar
23] Emperor Honda, Authorized Service Car De.	49] Star-Motors, Chevrolet Company, Kamthi Road.
24] Emperor-Honda, Tajshri Sai.	50] Tata Motors Services
25] Mahesh Automobiles, Lokseva nagar, Nagpur	51] Tata Motors/ Nangia Motors
26] Mahindra, Unnati Motors Pvt. Ltd, Kamthi road.	52] Total Cleaning Services
	53] Toyota, Grace Motors, Kamthi Road, Nagpur.

Table 3: Automobile service stations in Nagpur city (Category: Minor).

Name of Service Stations	
1] Jidewar Suzuki	24] Mamta Automobiles
2] A.K.Gandhi TVS	25] Mascot Honda
3] A.V. Scooters	26] Motor Bike
4] Accent Motors(Yamaha)	27] Nandu Automobiles
5] Adarsh Automobiles, Trimurti Nagar, Nagpur.	28] Nangia Suzuki, Yashwant Stadium.
6] Aditya Hero, Sitabuldi, Nagpur	29] Patni Bajaj
7] Aditya Hero Honda Automated Workshop, VIP Road, Dharampeth.	30] Ram Scooter & Bike Servicing Centre, Near NIT Garden, Trimurti Nagar

8] Arun Bajaj Motorcycles	31] Rane Auto Service Center.
9] Arvind Automobiles	32] Royal Bike Point, Near SBI
10] Autoage Automobiles	33] Satguru Sai Scooters
11] Ayesha Automobiles, Hingna Road.	34] Scooter-Bike Servicing Centre, Gokulpeth.
12] Bajaj Motorcycles	35] Shivam Automobiles/Raja Bike Servicing
13] Bike Stop	36] Shreejee Automobiles
14] Dilip Automobiles	37] Shri-Krushna TVS Service & Parts
15] Gurudeo Hero	38] Sourabh Motors
16] Hero-Surya Motors, Nari Road.	39] Sudarshan Motors, Ravi Nagar, Nagpur.
17] Indrayani TVS	40] Sunil Scooters & Servicing.
18] Jay Ambe, Hingna Road, Nagpur	41] Tajashree Honda
19] K.S. Lamba TVS.	42] TVS Scooters
20] Khade Automobiles	43] TVS Shri Krishna Automobiles
21] Komal Bike Point	44] Unnati Hero.
22] Kusumgar Hero	45] Vijay Scooters & Automobiles
23] Mahavir TVS & Honda Service Centre, Swalambi, Nagar	46] Yamaha/Vidarbha Motors Pvt. Ltd.

III. Results And Discussion

A Detailed survey of total 110 automobile service stations in and around Nagpur city was carried out of which 11 servicing stations were major, 53 servicing stations were medium and 46 servicing stations were minor (Table 1, 2 and 3). Automobile service stations are water intensive industry. Huge volume of water is used in cleaning vehicles. It has been observed that approximately 500 liters to 600 liters of water per Heavy vehicle (Tipper and Bus) is required for cleaning. Approximately 150 liters to 200 liters of water per vehicle is required for cleaning of four wheeler (car), minimum of 25 liters to 40 liters of water required for scooter and bike for cleaning while servicing. Much more amount of water is always required for vehicular washing as compared to vehicular cleaning, it differs depending upon the type and condition of vehicle too.

It has been also observed that, in large service stations like Jaika motors or Seva automotive, water requirement per day varies between 7000 liters to 9000 liters. Out of this total volume of water, 93% to 94% water is generated as wastewater. Seva automotive caters servicing of 70 to 80 vehicles per day out of which 40 vehicles are serviced for oil change and 50kg to 60kg solid waste has been generated per day while servicing vehicles in this service station. Photograph-1 shows the properly constructed ramp for vehicular servicing and underground tank for collection of wastewater. The Seva automotive has a properly constructed environmental management system which includes physico-chemical treatment methods as shown in photograph-2. Ketan Hyundai caters servicing of 50 to 55 cars/ day out of which 25 vehicles are serviced for oil change. 15 kg to 20kg/day of solid waste generated during servicing in Ketan Hyundai servicing station. Effluent treatment plant (MCON construction, Nagpur) was observed in working condition in this station. Jaika Motors Ltd., serves 10 to 16 commercial vehicles (trucks, tippers and buses) daily and oil is changed or refilled in 5- 7 vehicles daily. In Jaika motors well-equipped working effluent treatment plant (ETP- MCON construction, Nagpur) observed as shown in photograph-3. Most of the treated wastewater they use for washing and cleaning of vehicles. Approximately 35kg – 50 kg per day solid waste is generated in Jaika motors.

One of the service station at Swawlambi Nagar Nagpur serves for 15-20 bikes or scooters daily. Oil refilling is carried out in 8-10 vehicles per day. Primary underground treatment plant is used in this service station, but no effluent treatment plant. Photograph-4 depicts the wastewater collection tank of this service station.

Foremost automobile servicing station located at VIP road Dharampeth, caters services for 35 - 50 vehicles (bikes and scooters) daily and oil refilling is carried out in 12-15 vehicles per day. Effluent treatment plant was not working but only the primary underground treatment plant was observed in this service station. Wastewater generated is discharged directly in nearby nullah.

Photograph-1: Ramp with underground tank for wastewater collection at Seva Automotive, Nagpur.

Photograph-2: ETP of Seva Automotive, Nagpur

Photograph-3: ETP at Jaika Motors. Nagpur

Photograph-4: Wastewater collection tank of Service Station at Swawlambi nagar, Nagpur

Photograph-5: Photograph of Wastewater discharge point at VIP road, Nagpur

Water required for servicing of heavy vehicles in large service stations was found between 1000 liters to 9000 liters per day. Out of this, 90% to 94 % of water is generated as wastewater and mainly contains polycyclic aromatic hydrocarbons (PAHs), Polychlorinated Biphenyls(PCBs), heavy metals, detergents and other toxicants as shown in table 4 and table 5. Oil is used to lubricate various internal parts of the engine. Lubricating oil also serves as a corrosion inhibitor, wastewater generated from vehicular servicing contains oil (Koyama, 2004). The solid waste generated by major service stations was found to be approximately 50kg to 70 kg per day, 10kg to 17 kg per day solid waste in medium and 3kg to 7 kg solid waste per day generated by minor servicing stations. Cotton fibrous pads, plastic debris and oil laden sludge were observed in it. Total 11 service stations have installed Effluent Treatment Plants (ETPs). Study also reveals that most of the service stations are lacking basic infrastructure facilities for vehicular washing and wastewater treatment. The heavy vehicle servicing station located at Amravati Road caters service only to large automobiles. It does not have any effluent treatment system and wastewater is simply discharged openly.

Physico-chemical characteristics of wastewater generated from vehicle servicing stations are analyzed for Oil and Grease, Alkalinity as $CaCO_3$, Chemical Oxygen Demand (COD), Chloride as Cl^-, Phosphate as PO_4^-, Sulphate as SO_4^-, Sodium as Na^+, Alkyl benzene sulphonate and Magnesium as Mg^{2+} were detected as 989mg/l, 375mg/l, 78mg/l 178mg/l, 0.82mg/l, 35mg/l, 173mg/l, 2.0mg/l and 17.36mg/l respectively (Singru, *et. al.*, 2017). Values of PO4, TP (Total Phosphate), Oil & Grease, Alkalinity, $NO3^-$ and COD in car wash wastewater were reported more than permissible limit of effluent standard and not safe to discharge in water bodies (Nor Haslina Hashim and Nadzirah Zayadi, 2016). Wastewater from automobile service station contain heavy metals such as Copper, Cobalt, Iron, Cadmium, Nickel, Zinc and Manganese which were detected as 0.279mg/l, 0.069mg/l, 26.047mg/l, 0.021mg/l, 0.04mg/l, 0.530mg/l and 1.344mg/l respectively. Similarly, pH of this wastewater was 7.45. High concentration of heavy metals than permissible limit in the wastewater generated by car wash has reported during repairing of engine block and brake drums (Shete and Shinkar, 2014). PAH_s like Naphthalene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benz(a) anthracene and Benzo(a)pyrene were 32 µg/l, 3.29µg/l, 20.09 µg/l, 10.26 µg/l, 2.33 µg/l, 21.65 µg/l, 1.69 µg/l and 2.05 µg/l detected respectively and shown in table 4.

Table 4: Presence of Poly aromatic hydrocarbons in the wastewater discharged from Vehicle Service Stations (Singru *et.al.*, 2016).

Name of the poly aromatic hydrocarbon*	**Values** in µg/l.
Naphthalene	32
Acenaphthylene	0.27
Acenaphthene	0.84
Fluorene	3.29
Phenanthrene	20.09
Anthracene	10.26
Fluoranthene	2.33
Pyrene	21.65
Benz(a) anthracene	1.69
Chrysene	0.53
Benzo(a)pyrene	2.05
Indenol(1,2,3,-cd)pyrene	0.81
Benzo(g,h,i)pyrelene	0.14

* All the values are expressed in µg/l.

The United States Environmental Protection Agency (EPA) and World Health Organization (WHO) had identified sixteen PAHs as priority pollutants e.g. Benzo(a)pyrene, Benzo(a) anthracene and chrysene are considered as potential human carcinogens (Tuvikene, 1995). Wastewater generated by automobile servicing stations contain toxic wastes such as PAHs, PCBs and heavy metals, which do not degrade easily and persist in the environment for a longer time. Many constituents of this wastewater are carcinogenic and mutagenic in nature (Ayaoola and Akaeze, 2012). Polychlorinated biphenyls were detected through GC-MS analysis in wastewater discharged from automobile service stations which is shown in table 5 and in figure 2.

Table 5: Presence of Polychlorinated biphenyls (PCBs) in wastewater discharged from automobile service stations.

Sr. No.	Retention time (min)	Identified compound
1	16.74	2,3',4',5,5'-Pentachlorobiphenyl
2	24.40	Pthalate anhydride
3	29.29	2,2 tetradecane
4	29.99	Octadecane

Area of 1ppm (std.) 2,3',4',5,5'-Pentachlorobiphenyl= 43245675

Area of peak (RT, 16.74) = 10643

The concentration of, 2,3,4,5,5-Pentachlorobiphenyl was found to be 0.000246 ppm

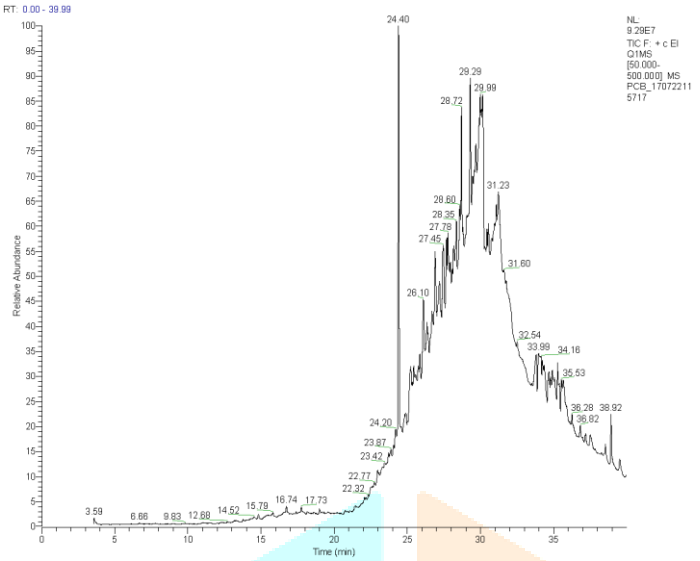

Fig. 2: GC-MS spectra of sample for PCBs

Detailed studies through Gas chromatography-mass spectrometry (GC-MS) analysis and toxicity tests gives deep insight into the toxicity level of the wastewater generated from automobile service stations. Hence, it is urgently needed to treat the complete volume of this wastewater prior to its discharge. Otherwise in the coming years the whole Nagpur city will face extreme water pollution problems. Impact of coolant wastewater laden with oil on fish *Lebistes reticulatus* has been reported (Satyanarayan, 2013). Before it is too late, pollution authorities should take stringent measures to treat this wastewater and save our aquatic fauna and flora.

Waste oil generation is also a problem. This is filled in drums, stored and used as fuel. As per the authorities, oil removal from the wastewater is not easily possible by simple settling / sedimentation methods. The reason being that oil content is in very small quantities and it forms an emulsion and contains dust, mud and muck present in the wastewater. This wastewater requires a physico chemical method for oil separation (Asha, et.al., 2016).

Apart from wastewater generation, solid waste is also generated in automobile service stations which consists of cotton fibrous pads, plastic bottles, bags, rubber, old tyres, foam, synthetic covers etc. Automobile service stations also generate electronic and electrical waste which can be recycled. Sludge from physico chemical treatment is hazardous in nature and is stored in drums and later sent to the common hazardous waste disposal facility of the authorized company for incineration or for secured land filling. Whatever little quantity of oil recovered is sold to the authorized dealers for reclaiming oil. At present few automobile service stations are treating their wastewater in an ETP and the treated wastewater is reused for gardening and also for car washing. This recycling and reuse should be advocated in all the service stations.

IV. Conclusion

The present study and status assessment of the automobile service stations in Nagpur city reveals that all the automobile service stations are in operation for long periods of time but most of the automobile service stations lack basic infrastructure facilities. Vehicles are washed in open water-logging areas. General environment was very dirty. Proper cement flooring, sloping for proper wastewater flow is needed. Wastewater discharged without proper treatment is causing water pollution. Thus it becomes imperative to conserve our precious water resources, flora and fauna from hazardous effects of oil pollution in near future.

In view of the lacunae observed during the study, it is needed to use effective technologies to reduce the wastewater generation and reuse the wastewater after treatment for vehicle cleaning.

V. Acknowledgement

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