International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor 5.46 Volume 7, Issue 01, January 2020
Website- www.aarf.asia, Email : editoraarf@gmail.com

GIS Mapping of Municipal Solid Waste Sources, Transportation Routes and Disposal in Bikaner City, Rajasthan, India

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Abstract:

In recent past many developing countries are facing serious problem of Municipal Solid Waste Management (MSWM). Waste management is defined as beneficial management of managing waste that is good for sustainable development. Population growth levels, exponential economic growth and higher living standards in the community have increased the rate of municipal solid waste (MSW) in urban areas of Indian towns and cities. Inadequate solid waste management poses risks to residents and impacts the natural environment negatively. In India, the volume of waste generation has been increasing rapidly over the last few years. According to the "Swachchh Sandesh Newsletter" by the MOHUA, as of January, 2020 about 147,613 metric tonnes (M.T.) of solid waste generated by India. The aim of this work was to develop a methodology for the optimization of the waste collection and transport system based on GIS technology. The methodology was applied to the Municipality of Bikaner city based on real field data. Bikaner City is situated between the parallels of 28º1'North latitude and 73º19'East Longitude in western Rajasthan. The city area covers 28, 466 Sq. km with about 8, 62,000 human populations. The study was conducted to discover the attributes of the types of Municipal solid waste and analyze the various sources, routes, collection and dumping sites of Bikaner city. The Arc Geographic Information System (GIS) network has been used with the help of Global Positioning System (GPS), to retrieve analyze the various sources, transportation routes, collection points, disposal sites and refilling sites of municipal solid waste. The generation rate of MSW has been approximated at 0.46 kg/capita/day and the total amount has been noted as 300 metric tons per day of MSW in Bikaner city. However, the present system is not effectively managed by the city authorities in absence of systematic collection, segregation, transportations and disposal for proper disposal for all 80 wards of the city. The focus of the study is to come out with GIS mapping of the waste sources, collection, transportation, segregation and disposal sites for better and effective waste management.

Key Words: Solid Waste, Arc GIS, GPS, Waste collection point, Disposal site, Refill site.

Introduction:

Solid waste management is the one of the major problems faced by today's world. There is an increase in commercial, residential and infrastructure development due to the population growth and it leads to negative impact on the environment. Municipal solid waste management (MSWM) is a greatest challenge before environment scientists, urban planners and decision makers of the world (Tripathi, *et. al.* 2022). Urban solid waste management is considered as one of the most tedious environmental problems facing by municipal authorities in developing countries.Collection of municipal solid waste (MSW) is an important step in every waste management program. It is one of the greatest challenges facing waste managers worldwide. Irrespective of the waste management method to be employed, the waste must first be collected. Collection processes may be tailored to meet the goal of the intended waste management method such as resource recovery or land filling. MSW collection usually involves people and a means of transport to a transfer station, treatment facility, or final disposal site (Worrell and Vesilind, 2012). Collection trucks then pick up containers, empty them at a final disposal site and return the containers to their locations. However, this collection system is associated with difficulties leading to uncollected waste as a result of overflow, ground dumping at collection sites, and open/indiscriminate dumping at unauthorized places.The rapid growth of population and urbanization decreases the non-renewable resources and disposal of effluent and toxic waste indiscriminately, are the major environmental issues posing threats to the existence of human being (Allen, *et. al.* 1997).The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses. GIS can recognize, analyze and correlate the spatial relationship between mapped phenomenon the software also has provision for querying thereby enabling policy makers to link disparate sources of information, perform sophisticated analysis, visualize trends, project outcomes and strategize long term planning goals (Malczewski, 1996). Waste collection Route optimization Collection and transportation is responsible for 70-80% of total waste management cost have proposed a GIS based collection and transportation model for MSMW and test checked it for Bikaner municipality.Generally municipal solid waste is collected and deposited in sanitary landfill, such unscientific disposal attracts birds, rodents and fleas to the waste dumping site and create unhygienic conditions (Suchitra, 2007).About 60 to 70% of this amount is spent on collection, 20 to 30% on transportation and less than 5% on final disposal of waste. The

utilization of Geographic Information Systems (GIS) and Global Positioning Systems (GPS) to capture and analyze spatial data is well known; and is growing in municipal solid waste management (MSWM) (Hua, 2003 and Sarptas, *et. al.* 2005). Information on geographic locations of municipal solid waste collection/dump sites (MSWCS) can help decision-making in MSWM, including collection route planning, dumps cleanup, and future sitting of collection sites. Although few studies have mapped solid waste collection systems (ChalkiasandLasaridi, 2009). The environment is heading towards a potential risk due to unsustainable waste disposal. It is a sensitive issue, which concerns about serious environmental problems in today's world. The present situation of direct dumping of the waste without proper inspection and separation leaves a serious impact of environmental pollution causing a tremendous growth in health-related problems. Domestic, industrial and other wastes, whether they are low or medium level wastes, they are causing environmental pollution and have become perennial problems for mankind.Use of these techniques in solid waste management supports in capturing, handling, and transmitting the required information in a prompt and proper manner (Singh, 2019).The Geographical Information System (GIS) can provide an opportunity to integrate field parameters with population and other relevant data or other associated features, which help in selection of sites. Site selection procedures can benefit from the appropriate use of GIS.

Study Area:Bikaner City is situated between the parallels of 28° 1' 22.566" North Latitude and 73° 18' 42.8976" East Longitude. The city area covers 28, 466 Sq. km with about 8, 62,000 human populations as shows in (Figure 1). Bikaner city is divided into five Zones and further subdivided into 80 wards by the municipal authorities. Bikaner city is spread over the area of 28, 466 Square Kilometer out of which the area of Bikaner Municipal Corporation (BMC) is about 155 sq. km. (BMC, 2020). Every year BMC spends on average 18% of its total budget on solid waste management. It is situated in the Thar Desert; Bikaner was considered an oasis on the trade route between Central Asia and the Gujarat coast as it had adequate spring water. The strategic location of Bikaner on the ancient caravan routes that came from West/Central Asia made it a prime trade centre in that times (*http://rajasthantourism.gov.in*).

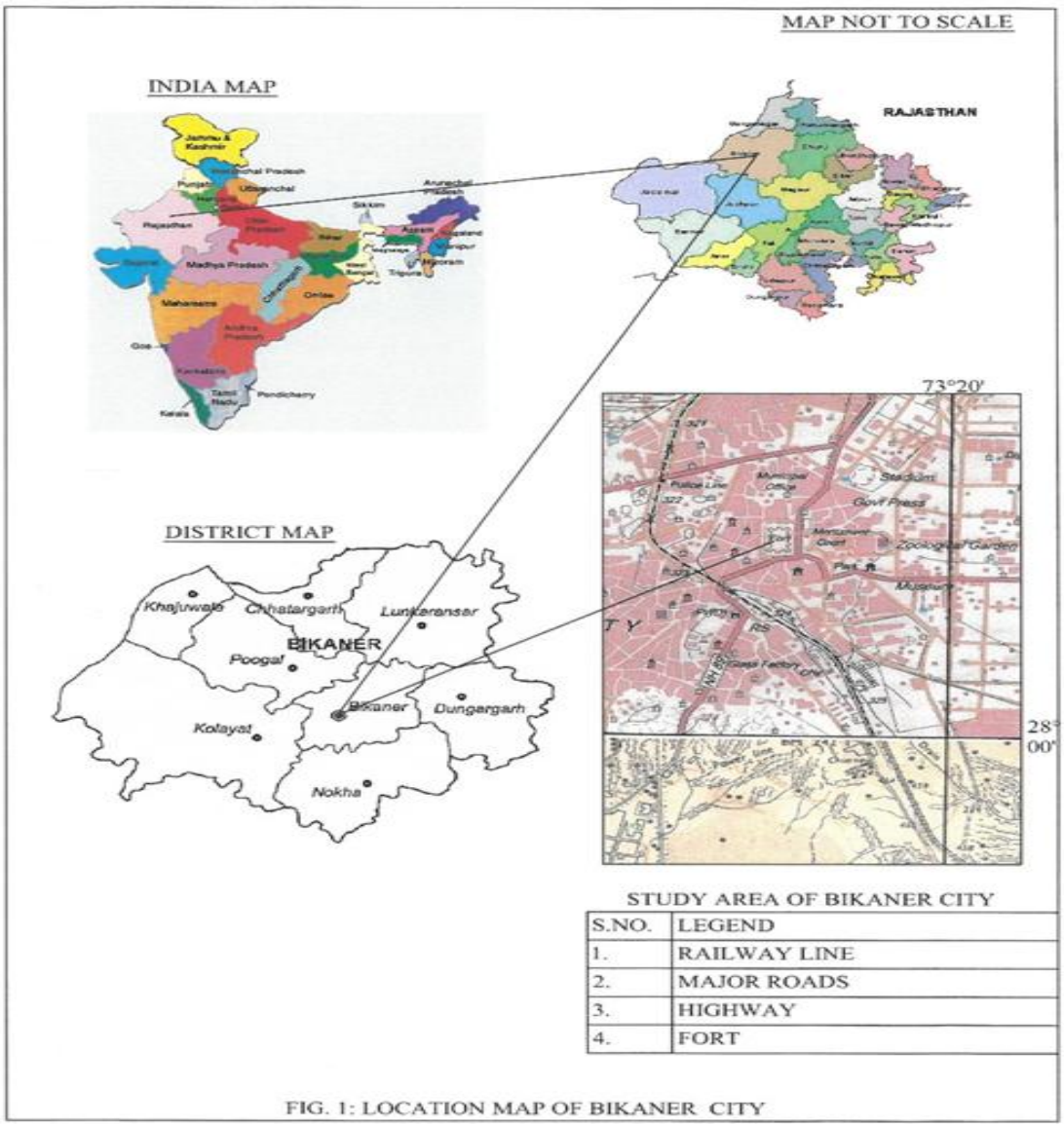

Figure 1 Location of the Study Area in the Bikaner City, Rajasthan, India

Methodology:

The aim of this work was to understand the present practices of the solid waste sources collection transport system and disposal and mapping with based on GIS technology. The methodology was applied to the Municipality of Bikaner city based on real field data (Karadimas, 2008).

GIS (Geographic Information System) - It is a computer tool used for capturing storing querying analyzing and displaying spatial data from real world for a particular set of purposes. This technique is used to generate optimal route for collecting solid wastes. GIS is a tool that not only reduces time and cost of site selection, but also provide a digital data bank for future monitoring program of site. Show cased application of GIS in solid waste management for Bikaner city (Shobha and Rasappan, 2013).A geographic information system

(GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyze, and understand patterns and relationships. With GIS technology, people can compare the locations of different things in order to discover how they relate to each other.GIS can use any information that includes location. The location can be expressed in many different ways, such as latitude and longitude.

A) Data Entry – Arc View GIS software 10 is used to create maps and for analysis of data base.

B) Mapping Technique -The Bikaner city map was obtained from the District Town Planning office. The details were identified using the geographical coordinates. The map was scanned using the HP Precision scan jet 5200c at 600dpi and the scanned images were stored as JPEG files, which were edited wherever necessary, using MS Photo Editor. Scanning results in the conversion of the image into an array of pixels thereby producing an image in the raster format. A raster file is an image in a series of dots called pixels or picture element that are arranged in rows and columns in a matrix format.

The raster images were opened in Arc view GIS as a raster layer using JPEG interchange format. Later this image was projected using projection of geographic latitude and longitude. Registration and Transformation was done to convert the image to real world coordinates. There are two types of transformation techniques, where the first one involves the X and Y co-ordinates recorded in Notepad or dbase being opened in Arc View. The option "Add Table" presents in Arc View adds the X, Y coordinates in the Notepad or dbase to the map, out of which the points were created. The created points were coordinated to that of the raster layer.

Similar features to that of the points were identified in the raster layer and a source point was selected in the raster map. Using that, the destination point was given to the text / dbf map. The raster later was thus assigned the real world coordinated or the ground control points of the study area. On completion of the transformation with the above method, over the raster layer, a new layer is digitized with special points. The entire layer was saved as a shape file.

C. Thematic Mapping – For the present study natural break classification techniques were used to classify sources, routes, disposal sites for thematic mapping.

Results and Discussion:

GIS Mapping of Municipal Solid Waste Different Sources:

A total of 7 Municipal Solid Waste Management (MSWS) (including 320 households, 583 hotel and restaurants, 15 markets, shops and offices, 40 Hospitals) were main sources of Municipal solid waste in Bikaner City. BMC has provided container bins in the major market areas for storage of waste. Main market places in Bikaner city are Rani Bazaar, Super/ Main Market, Kote Gate, Bada Bazar they consist 2.5 % out of total waste. Considering that there are about 583 numbers of hotels and restaurants in the city there would be around 5.68 tonnes of waste each day. The Bikaner city is estimated to have total roads of about 458 km in BMC limits spread across all the 60 wards. On an average each sweeper sweeps around 700-800 Sq meters in per day.Health care facilities operating in Bikaner have obtained connectivity with M/s E-Tech Project covers area is about 150 Km. Total quantity of biomedical waste collected from 264 hospitals, whereas bed capacity is 4503 from member health care facility. GIS mapping of selected total 40 hospitals according to their bed capacity in the study areas shown in Figure 3. Total generated biomedical waste is 2600kg /day out of which 520 kg/day treated by incretion, 6.5 kg/day by Autoclaving, 3 kg/day by shredding and 200L/ day effluent treated.

The resulting feature layer was employed to develop a Solid waste different sources mapping of vegetable markets, Hospitals. According to GIS mapping 6 major vegetable markets in the city these are Daga Building KEM Road, Baido Ki Pirol, Rani Bazar, Phad Bazar, Kote Gate, Pugal Road they contribute vegetables, cartoon, plastic, polythene. Residue vegetable eatable for cows of the city and rest of other waste are carried by rag pickers and sell to whole sailor of waste as shown in Table 1 and Figure 2.

Table 1: Estimation of the Municipal Solid Waste in Bikaner City (%)

Sources of Waste	Percentage
Households	39.3%
Hotel and Restaurants	36.5%
Street Sweeping	10.8 %
Markets	2.5%
Shops and Offices	2.7%
Hospital	8.2%
Total	**100%**

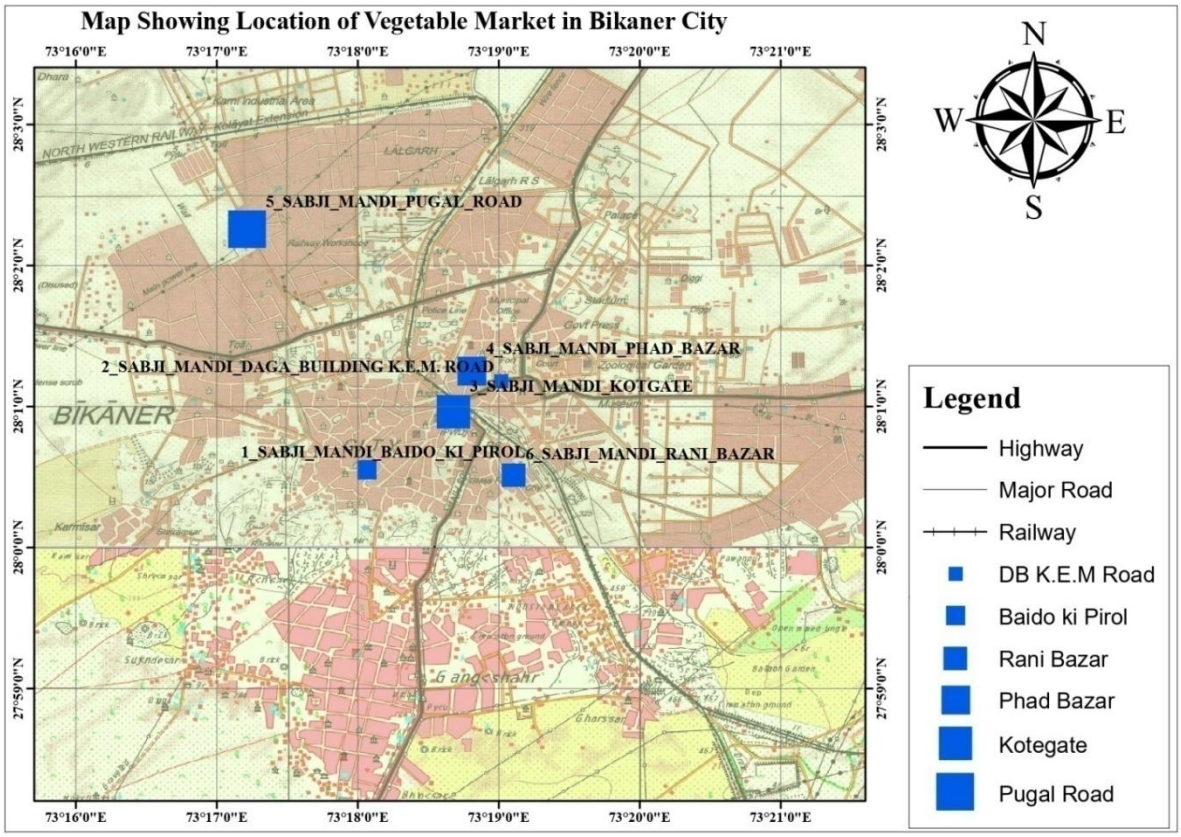

Figure 2: location of Vegetable market in Bikaner city

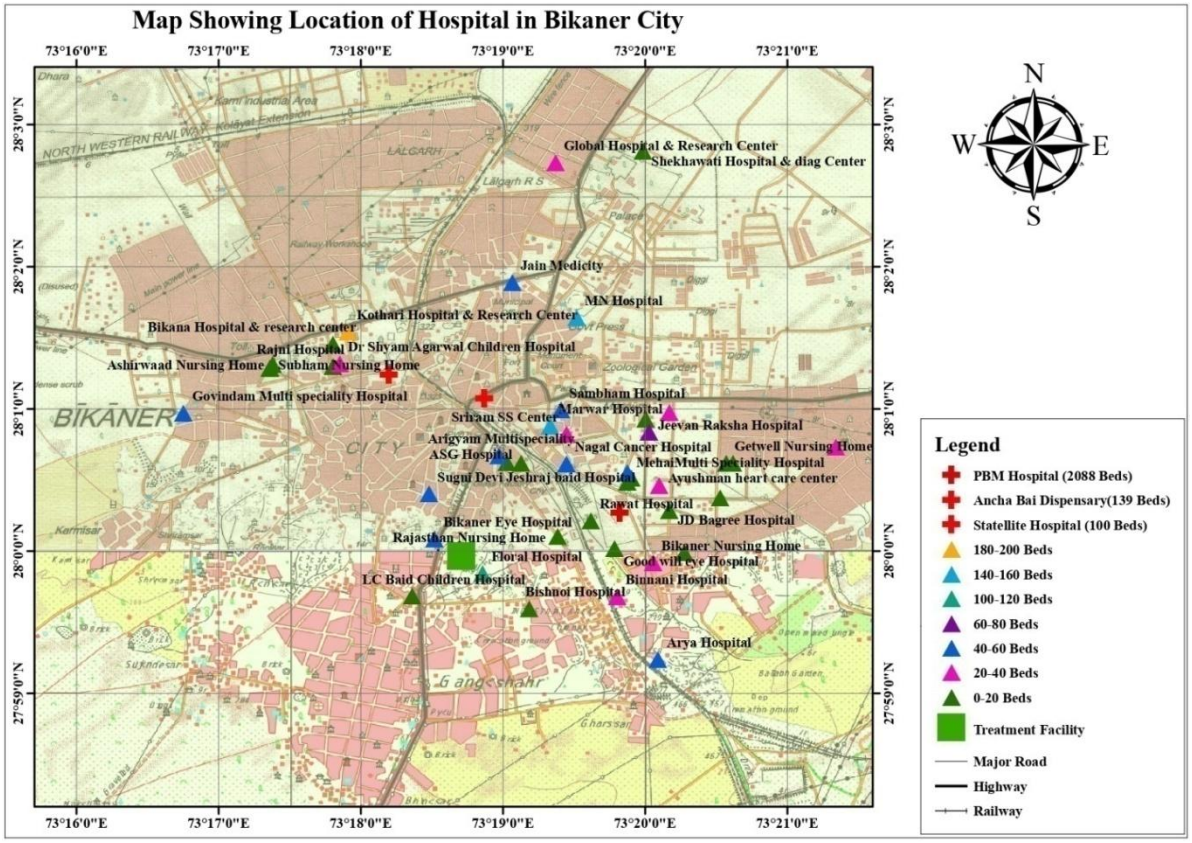

Figure 3: Location of the Hospitals in Bikaner City generating biomedical waste.

GIS Mapping for Municipal Solid Waste Collection and Transportation:

The results of this analysis are shown in Figure 4. Out of the 55 transported routes, 11 (about 50%) had containers and no ground dumping of waste, 24 (39% approximately) had containers with ground dumping of waste, and 20 (nearly 27%) are without containers with ground dumping. Overall, about 67% of MSWCS are experiencing ground dumping, which suggests poor MSWM.

Plate 1: Collection of waste by JPG and loadedin waste Tractor near Dungar college road

The 14 sites experiencing open dumping appear relatively located out of inner town suggesting that the collection system is mostly concentrated in the inner city. There are 132container bins of 3 cum, 2.5 cum, 1.1 cum containers. These container depots are considered as part of the transport system. There is no intermediate transfer station in Bikaner. Records from the waste managers of Bikaner Municipality showed that 37 container sites were in the town. It may be that these managers are not aware of the dumping going on in most of the 14 sites without containers. This map and its relational database could be a great resource to help these waste managers identify the 14 sites for proper management. The collection bins are of size 3 cum, 2.5 cum, 1.1 cum capacity and there are 132 bins spread across the city. There is an active sweeping, secondary collection and transport systems operational with an assessed efficiency of collection of about 90%. Considering that each bin of 3 cubic meter sizes contains a waste of 1.5 tons, around 25-30 tons of market waste is generated each day from markets. The street sweeping work is carried out from 6.00 AM to 12.00 PM in the morning hours.

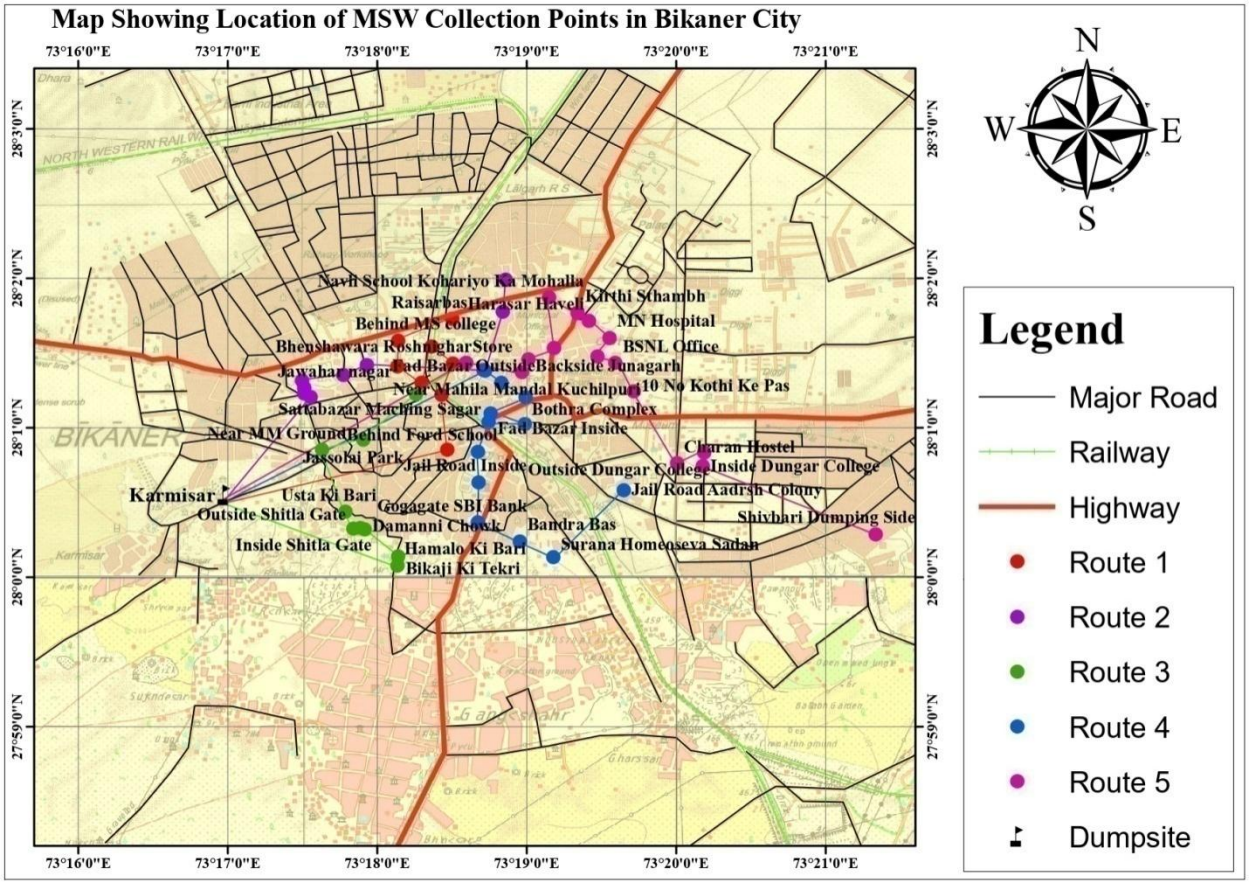

Figure 4: Location of Municipal solid waste collection points in Bikaner city

Transportation of the solid waste generated in the city presently is being managed by Bikaner Municipal Corporation BMC. Primary transportation refers to transporting of waste generated from waste generators to the waste storage depot. Primary transportation of door-to-door waste collection is done through 1.11 cum small vehicles in Bikaner. There are no intermediate storage depots in Bikaner except container bins. Secondary transportation refers to collection of waste from intermediate storage points like dumper bins and open points to disposal unit. BMC is presently managing the secondary transportation with its vehicles. Compactor, dumper placers and tractor trailers are used as secondary transportation vehicles. MSWC geodatabase, which can help in planning and management decision making on MSW, is non-existent in Bikaner City. Thus, the creation of this database should be a useful tool toward improving the MSW collection system in Bikaner Municipality.

GIS Mapping of Municipal Solid Waste Disposal Site**:**

Some routes sites not having containers and ground dumping are an indication that those sites have inadequate containers and may need additional containers to eliminate or minimize ground dumping. Though we lacked adequate resources to quantify ground dumping during the field survey, it is worth noting that dumped waste range from young to matured and low to relatively higher in volume. BMC has set up Municipal Solid Waste disposing site at Goga gate, Karmisar Shiv valley, Vallabh Garden as shown in Fig 5. Existing Vallabh Garden dumping site is located at a distance of about kms from the city center. The total area of the landfill site is about 2 acre approx. area. The landfill site is walled on all sides.

Plate 2: Waste dispose at Vallabh garden dumping site in Bikaner city

The facility has been provided with a watchman's room. BMC has deployed trip entry recorders for the trips of each vehicle on all days. The disposal site is being provided with a 24 hour watch man and weighing bridge. The waste brought to the depot by compactors, dumper placers and tractors is dumped inside and JCB is deployed to form heaps of the waste. The waste heaps are not covered with inert material and no scientific waste processing is done on site.

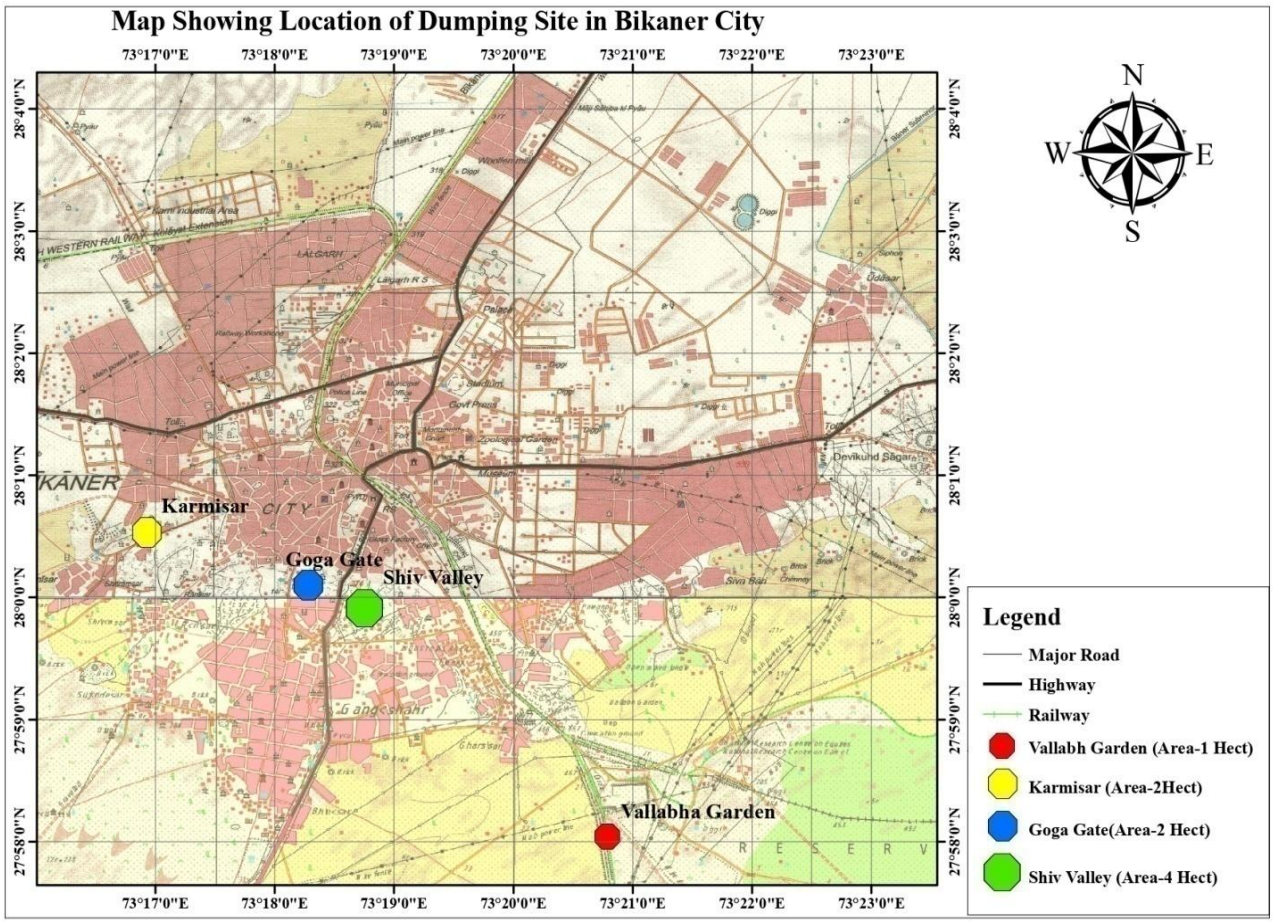

Figure 5: Location of Dumping Sites in Bikaner City

Plate 3: Weighing of loaded waste in tractor at Pandit Dharam Kanta in Bikaner City

Table 2: Types of transportation vehicle to carry the Municipal Solid Waste per day in MT

Types of vehicles	No of Units	Shift	Average no. of trip per day	Capacity (metric tons)	Total waste transported daily (metric tons)
Pvt.Tractor	35	Morning	105	1.05	157.05
Pvt. Tractor	20	Evening	40	1.05	60.00
Govt. Tractor	07	Morning	21	1.05	31.05
Dumper	11	Morning	33	2.05	82.05
Dumper	02	Evening	04	2.05	10.00
Auto tripper	04	Morning	12	0.25	03.00
Refuse Container	01	Morning	11	05.00	05.00

**Note Total waste transported by vehicles is 349.00 tons per day according to BMC (Nagar Nigam, 2020).*

Refill Site:Use of GIS Mapping in the management of Solid Waste, Route, Dumping Site, Collection site, Refilling Site. Recently house to house and transported to waste city dumping yard presently at Vallabh Garden area is about 9 hectors approx. areas. Open dumping site is occurred in many parts of the city.The refill station concept could do significantly reduce packaging waste without compromising the price or quality of liquid products as shown in table 3 and Figure 7. In Bikaner city all corner rag pickers use thrown plastic bottles and other recyclable material for selling and its help for their livelihood.

Table 3 Proposed refilling site for municipal waste management in Bikaner city

S.No.	Longitude	Latitude	Area (HA)	Location
1	73.3826E	28.0939N	25.94593955	KG Mines Beechhwal Rural
2	73.3801E	28.0785N	50.62061272	Beechhwal Rural
3	73.4376E	28.0436N	22.20699222	RidmalsarPurohitan
4	73.4619E	28.0470N	8.15370869	Himtasar
5	73.4682E	28.0486N	4.05275834	Himtasar 1

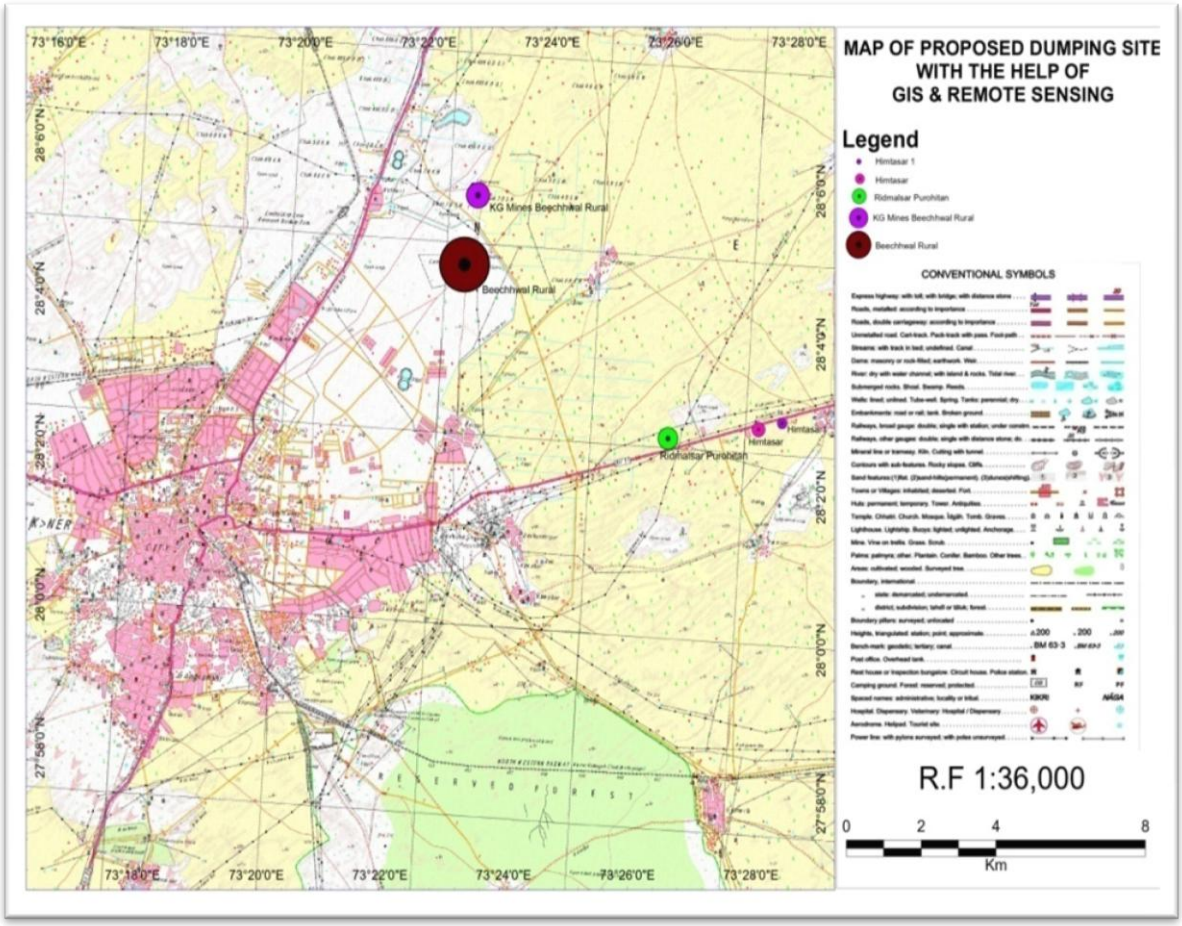

Figure 6: Location of dumping at existed mining area in and around city

The creation of GIS maps for Bikaner town can be utilized for MSW generation sources for sustainable waste management. From the data collected, an analysis of collection efficiency of the Bikaner Municipal collection system was conducted based on communal container availability and ground dumping of waste. The spatial relationship between Transfer routes, dumping sites was examined. The findings show high concentration of MSWCS in the inner city of Bikaner. significant percentage of container sites characterized by ground dumping and higher number of open dumps in Bikaner town were also observed, suggesting weakness in the MSW collection system. This study illustrated that MSWM indeveloping counties could be improved using GIS technology. The approach used for Bikaner city could be replicated in many other cities and urban towns in Bikaner as well as other developing countries with similar MSWM problems to enhance policy and decision making.

Conclusion:

According to study used of GIS the selection of most suitable site for disposal of solid waste in Kolkata city (Paul, 2014). A well as another study held in Pondicherry its stated that GIS

useful for ensure minimum damage to the environment and geology water supply resources, land use, sensitive sites, air quality ground water quality from testing GIS system (Sumathi, 2008). Another study conducted in Sfax city in Tunisia outcome of this study is developed to improve efficiency of waste collection and transportation by the help of Arc GIS network tool (*www.smartcitiescouncil.com*). Collection of Municipal Solid Waste (MSW) is important in every waste management program. Communal container collection systems appear most prevalent in many developing countries. However, this collection system is associated with problems such as overflow of waste containers, ground dumping at collection sites, and open/indiscriminate dumping at unauthorized places. The spatial distribution of these activities presents potential contamination challenges to water resources. Spatial information on Municipal Solid Waste Collection/Dump Sites (MSWCS) is essential for Municipal Solid Waste Management (MSWM) decision-making, including sources and collection route planning, and dumps cleanup. This study demonstrated how GIS and GPS can be used to enhance decision making on MSW and water management.

As the main aim of this work is the application of an operational waste collection scheme, future work will focus on the enhancement of the proposed approach. Advanced sectorization can be further investigated, since it is a significant aspect of the collection procedure. GIS technology can be used at local level for the optimization of the waste collection procedure, with considerable financial and environmental savings**.** The municipal officers and local workers involved in solid waste management should be clear about the function and their role in terms of managing cities effectively with help of GIS system. Thematic maps will help to identify and monitor more generated waste. The assignment of waste management comes to be more unpredictable as the populace increments. The moving capability of GIS in taking care of extensive volume of geospatial information requires its inclination to the utilization of accepted technique for waste management. In this study GIS innovation was utilized for the advancement of a strategy for the optimization of blended MSW gathering. The system employments different geographical information (way organize, area of waste canisters, arrive utilizes and so on) in co-operation with progressed spatial dissection GIS instruments. There is need to improve waste management practices better data monitoring and management with the help of GIS. GIS can be also used at various levels in MSW management in various cities of India. Promoting waste markets and recycling would also create awareness to reduce the total volume of waste at the landfill. This study demonstrated how GIS mapping can be used to enhance the waste management in the urban areas. We

should not be forgetting that solid waste also carries the pesticide contamination and that kind of study is very much needed to be done in the future as pesticides are reported to be potent carcinogens, mutagens and teratogens and pose threats to faunal and human life.More scary studies have indicated that we have largely over looked the darker side of these chemicals as organochlorine pesticides (OCPs) are reported to be carcinogenic (Mathur et al, 2002 &Ingber et al 2013) mutagenic (Ingber et al 2013&Yaduvanshi et al 2012) teratogenic (Yaduvanshi et al 2012 & ATSDR. Atlanta, GA.1994) immunosuppressive (Repetto. R & Baliga. S.S, 1997 &Corsinia et al, 2003) create endocrine dysfunction such as hypothyroidism or high estrogenic activity (Dewailly et al 2000&Rathore et al, 2002) disturb reproductive processes (Pant et al ,2007 & Tiemann.U. 2008) growth depressants (Colborn et al, 1993&Mercier. M, 1981) induces several psychogenic and neurogenic abnormalities in adult stages (Mactutus& Tilson, 1986 & Van Wendel de Jood et al,2001) and are associated with abortions, premature deliveries, still births and infants with low birth weights (Saxena et al, 1981; Saxena et al, 1980; Tyagi et al 2015; Chen. Q et al 2014& Sharma & Bhatnagar, 1996). OCPs have been in use in India nearly for a half century now. Even after having clear cut evidence suggesting that these chemicals have the ability to eliminate entire species from the planet, the annual consumption of pesticides in India is about 85,000 tons of which OCPs comprise the bulk (India Environment Portal Knowledge for change, 30/10/1998.). Therefore, today OCPs are perhaps the most ubiquitous of the potentially harmful chemicals encountered in the environment and are still widely detected in humans despite the considerable decline in environmental concentrations (Dewan et al. 2003). This kind of environmental Contamination with organochlorine pesticides (OCPs) has also been reported by Sharma and her coworkers in 1996 from Jaipur City. She reported contamination of human samples like mothers' blood, cord blood, placenta and mothers' milk with OCPs. Presence of pesticides with OCPs shows that how these xenobiotics have contaminated our Mother Nature and now faunal diversity is facing danger of existence and animals are not staying away from this potential danger. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and reaching out to all faunal diversity. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and the pesticides reach the human body through various sources mainly by absorption form the gastrointestinal tract through contaminated food chain, are circulated in blood, stored milk and secreted during lactation resulting in sufficient neonatal intake. The battle against the harmful insects would be much less costly

and more efficient, and the problem of contamination of the environment by toxic materials would be vastly reduced, if insect activities are controlled by natural means. The use of pest-specific predators; parasites or pathogens; sterilization of insects with the help of radiations; trapping insects using insect attractants like pheromones; use of juvenile hormones or hormone inhibitors may therefore be suggested as alternate ways of pest control (Sharma, M. 1996; Sharma, M. & Bhatnagar, P, 2017).

Acknowledgment:

We would like to acknowledge and give warmest thanks to our Professor V.K. Singh Vice chancellor and Head, Department of Environmental Science, Maharaja Ganga Singh University, Bikaner, Rajasthan for providing facilities in the department and to the Raj rishi Government Autonoms College, Alwar, Rajasthan. We would also like to thank Geomin solution Pvt. Ltd. Member as Geologist Suraj Bhan Singh for creating Map from ArcGIS and sanitary inspector Om Prakash of Nagar Nigam of Bikaner City.

References:

1. Agency for Toxic Substances and Diseases Registry (ATSDR)/US Public Health Service, Toxicological Profile for 4,4'-DDT, 4,4'-DDE, 4, 4'-DDD (Update). ATSDR. Atlanta, GA.1994.
2. Allen AR, Dillon AM, O"Brien M. (1997). Approaches to landfill site selection in Ireland. Engineering Geology and the Environment. Balkema, Rotterdam pp 15691574.
3. BMC. (2020). Nagar Nigam Bikaner. Door to Door MSW collection & Transportation for Bikaner city Report.
4. Chalkias, C. and Lasaridi, K. (2009). A GIS Based Model for the Optimization of Municipal Solid Waste Collection: The Case Study of Nikea, Athens, Greece. Technology, 1, pp.11-15.
5. Chen.Q., Zheng.T., Bassig.B., Cheng.Y., Leaderer.B., Lin.S., Holford.T., Qiu.J., Zhang.Y., Shi.K., Zhu.Y., Niu.J., Li.Y., Guo.Y.H., Huand.X and Jin.Y.(2014): Prenatal Exposure to Polycyclic Aromatic Hydrocarbons and Birth Weight in China," Open Journal of Air Pollution, vol.3, pp. 100-110.

6. Colborn.T., Vom Saal. F.S., Soto A.M (1993): Developmental Effects of Endocrine-Disrupting Chemicals in Wildlife and Human," Environ. Health. Perspect, vol. 101, no. 5, pp.378-384, October.
7. Corsinia.E., Sokootib.M., Gallia.C.L., Morettoc.A and Colosiob.C. (2013): Pesticide induced immunotoxicity in humans: A comprehensive review of the existing evidence,Toxicology. vol. 307, pp. 123–135, May.
8. Dewailly.E., Ayotte.P., Bruneau.S., Gingras.S., Belles-Isles. M and Roy.R.(2000): Susceptibility to infections and immune status in Inuit infants exposed to organochlorines, Environ Health Perspect., vol.108, no.3, 205–211, March.
9. Dewan, P., Jain, V., Gupta, P., & Banerjee, B. D. (2013). Organochlorine pesticide residues in maternal blood, cord blood, placenta, and breastmilk and their relation to birth size. Chemosphere, 90(5), 1704-1710.
10. ***http://rajasthantourism.gov.in.***
11. Hua, H.Z.X. (2003). Application of GIS System into the Management of Municipal Solid Waste. Liaoning Urban and Rural Environmental Science & Technology, 4, pp.0-18.
12. India Environment Portal Knowledge for change, 30/10/1998.
13. Ingber,S.Z., Buser,M.C., Pohl,H.R., Abadin,H.G.,Murray, H.E.,Scinicariello.F.(2013): DDT/DDE and breast cancer: a meta-analysis. RegulToxicolPharmacol., vol. 67, no. 3, pp. 421-33.
14. Karadimas N.V and Loumous V.G. (2008). GIS based modeling for estimation of municipal solid waste generation and collection. Waste management and research, 26, pp. 337-34.
15. Mactutus, C.F and Tilson, H.A (1986): Psychogenic and neurogenic abnormalities after perinatal insecticide exposure. In: Hand book of behavioral teratology. Ed. by Edward, P.R. and Charles, V.V. Plenum Press, NY, 335-91.
16. Malczewski, J. (1996). A GIS based land use suitability analysis, a critical overview, Program. Plan. 62(1) pp. 3-65.
17. Mathur, V., Bhatnagar, P., Sharma, R. G., Acharya, V., &Sexana, R. (2002): Breast cancer incidence and exposure to pesticides among women originating from Jaipur. Environment international, 28(5), 331-336.

18. Mercier. M (1981): Criteria (Dose Effect Relationships) for Organochlorine Pesticides Report, Published for the Committee of the European Communities by Pergamon Press.
19. Pant.N., Kumar.R., Mathur.N., Srivastava.S.P.,Saxena. D.K and Gujrati.V.R.(2007): Chlorinated pesticide concentration in semen of fertile and infertile men and correlation with sperm quality" Environ Toxicol and Pharmacol., vol. 23, no. 2, pp. 135–139, March.
20. 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, Volume 64 Issue (7), pp. 846–861.
21. Rasappan, S. K. (2013). Application of GIS in solid waste management for Coimbatore City. International Journal of Scientific and Research Publications Volume (3), Issue 10 pp 1-5.
22. Rathore. M., Bhatnagar. P., Mathur. D and Saxena. G.N. (2002): Burden of organochlorine pesticides in blood and its effect on thyroid hormones in women," Sci Total Environ., vol. 295, no. 1–3, pp. 207–215, August.
23. Repetto.R and Baliga.S.S.(1997): Pesticides and Immunosuppression: The Risks to Public Health," Health Policy Plan., vol. 12, no. 2, pp.97-106.
24. Sarptas, H., Alpaslan, N. and Dolgen, D. (2005). GIS Supported Solid Waste Management in Coastal Areas. Water Science & Technology, 51, pp. 213-220.
25. Saxena, M.C., Siddiqui, M.K.J., Bhargava, A.K., Seth, T.D., Krishnamurti, C.R and Kutty, D. (1980): Role of chlorinated hydrocarbon pesticides in abortions and premature labour. Toxicology. 17. 323-31
26. Saxena, M.C., Siddiqui, M.K.J., Seth, T.D and Krishnamurti, C.R. (1981): Organochlorine pesticides in specimens from women undergoing abortion, premature and full-term delivery. J. of Anal. Toxicol.5, Jan/ Feb.
27. Sharma, M. & Bhatnagar, P. (2017). Pesticide burden in women from Jaipur in relation to ethnicity, religion and addiction habit. International Journal of Environmental Science and Development, Vol. 8, No. 3, 216-220.
28. Sharma, M., & Bhatnagar, P. (1996). Organochlorine pesticides and preterm labour in human beings. Current Science, Vol. 71, No. 8, pp. 628-631.
29. Sharma. M. (1996). Transplacental movement of pesticides in women from Jaipur. Ph.D. thesis submitted to department of Zoology, University of Rajasthan, Jaipur, Rajasthan, India.

30. Singh, A. (2019). Remote sensing and GIS applications for municipal waste management. Journal of Environmental Management. Elsevier, 243, pp 22-29.
31. Suchitra, M. (2007). Outside: Burnt or buried, garbage needs land. Down to Earth, 15 March, pp. 22–24.
32. Sumathi, V.R., Natesan, U. and Sarkar, C. (2008). GIS-based approach for optimized sitting of municipal solid waste landfill. Waste Management, Volume 28, Issue, 11 pp. 2146-2160.
33. Tiemann.U. (2008): In vivo and in vitro effects of the organochlorine pesticides DDT, TCPM, methoxychlor, and lindane on the female reproductive tract of mammals: A review, Reproductive Toxicology., vol.25, no. 3, pp. 316–326, April.
34. Tripathi, D. K., Kumar, M.and Biswas, V. (2022). Spatial Modeling for Municipal Solid Waste Management Using Remote Sensing and Geographic Information System. Advances in Geographical and Environmental Sciences. Springer Book, 483-497.
35. Tyagi.V., Garg.N., Mustafa. M.D., Banerjee, B.D and Guleria. K. (2015): Organochlorine pesticide levels in maternal blood and placental tissue with reference to preterm birth: A recent trend in North Indian population, Environ Monit Assess., vol.187, no. 7, pp. 471, July.
36. Van Wendel de Joode.B., Wesseling.C., Kromhout.H., Monge. P., García. M and Mergler. D. (2001): Chronic nervous-system effects of long-term occupational exposure to DDT, Lancet, vol. 357, no. 9261, pp. 1014–1016, March.
37. Worrell, W.A. and Vesilind, P.A. (2012). Solid Waste Engineering. 2nd Edition, Cengage Learning, Stamford.ISBN-13: 978-1-4390-6215-9.
38. www.smartcitiescouncil.com.
39. Yaduvanshi. S.K, Srivastava.N, F. Marotta.F, S. Jain.S and H. Yadav.H.(2012): Evaluation of micronuclei induction capacity and mutagenicity of organochlorine and organophosphate pesticides, Drug Metab Lett., vol. 6, no. 3, pp. 187-97.