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RESEARCH ARTICLE

A STUDY ONANTI-MICROBIAL RESISTANTENVIRONMENTAL BACTERIA FROM AURANGABAD CITY MUNICIPAL AREA MAHARASHTRA, INDIA

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Abstract

With rapid industrial development and progress of civilization, the problem of increase in waste generation becomes more complex in urban areas like Aurangabad fastest growing city in Asia in Marathwada, Maharashtra in India. In this study,we explorethe diversityofbacteriainsewagewastewater withthe assessment oftheantibiotic resistance of the isolated bacteria. The water samples: sewage wastewater was collectedfrominaround the Aurangabad City of Maharashtra, India, and was processed for isolation, which was characterized for identificationfollowingphenotypictechniques.A total of 09 bacteria were isolated from the sewage samples studied, among which 3 were gram-negative and 06 were gram-positive. Our present study evidently revealed that thesewageasconfirmedinthecurrentstudy,the growth ofgram-positive rods shape cocci, and evengram-negative rods too; in which the diversity of gram-positivebacteria was found greater, as we compared to the gram-negative bacteria.Thesebacteria isolateshave the potential to cause infections andpossess varied antibiotic resistance. Thus,thisisimperativefortheregularvigilanceofsuchwastewaterbacteriato combatbacterialmultipleantibioticresistance. We can conclude that the useful bacteria might be isolated from the Aurangabad city area which will be helpful for bioconversion of sewage/solid waste management.

Introduction:-

The current environmental concerns have stimulated the interest of institutions, industries, and the public in two critical concepts: sustainability and circular economy (Ingrassia et. al., 2020, 2019). Solid Waste is defined as waste type that includes principally household waste/domestic waste with sometimes the addition of commercial waste collected by a municipality within a given area. Whichever solid or semisolid form and usually eliminate industrial hazardous wastes. Microorganisms that reside in solid wastes are clustered under Solid Waste Microflora (SWM). The most common microorganisms that normally originate in solid waste are bacteria and fungi. In the Niger Delta region of Nigeria, it has been reported that gram-positive and gram-negative pathogenic bacteria were isolated from fishpond water (Njoku, 2015). From samples of residential water, Mukhopadhyay (2012) recovered a large number of antibiotic-resistant bacteria, including coliforms, Pseudomonas aeruginosa, and Enterococcus spp. Mulamattathil (2014) provided examples of how to distinguish and identify bacteria from sewage water samples and established the profiles of bacteria's antibiotic resistance. These microorganisms use the components of the waste as the

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substrate for their growth. They produce and increase these wastes by utilizing the various mechanisms that make up solid waste. Further, a wide variety of pathogenic microorganisms have been reported to be up to date in these organic wastes. No significant study was carried out in the field of solid waste microflora and pathogenic bacteria in the study area of Aurangabad City Municipal Corporation area (AMC). The occurrence of resistancetomultipleantibioticsamongbacteria,havingthecapacityto cause many health threats to humans, is not uncommon, in ourtimes, in the environment, including aquatic bodies observed by various researchers such as Poonia, 2014; Zang, 2009 and Baquero, 2008. So, we are interested to investigate the Bacteria present in sewage wastes and to find out its applications since, the beginning of humankind has been generating waste in the form of bones and other parts of animals they slaughter for their food or the wood they cut to make their carts, with the progress of civilization, the waste generation become more complex in nature. Microbial antibiotic resistance has been stated as one ofthe significant threats to both human and environmentalhealthat the moment, despite the fact that antibiotics have successfully treated numerous life-or-death situations in the past in clinical settings (Van Boeckel, 2014). Taneja, 2019 provedused a microbiological examination of drinking water from various institutions in North India to demonstrate the existence of coliform bacteria, including Escherichia coli. According to Ajayi, gram-positive bacteria like Streptococcus species, Staphylococcus aureus, and Bacillus species, as well as gram-negative bacteria like Escherichia coli, Pseudomonas species, Klebsiella species, Enterobacter species, Proteus species, Cytrobacter species, and Shigella species, were found in the pond water in 2014. Multiple antibiotic-resistant gram-negative bacteria have been identified as organicpollutants of natural water sourcesKrumperman,1983 and Adefisoye, 2017. In our earlier research, Nandi, 2016, showed that gram-negative and gram-positive bacteria from environmental sources exhibit a wide variety of MAR indices. Determining the existence of potentially dangerous bacteria in sewage and the forms of the isolated microorganisms' antibiotic resistance are the two goals of the currently underway investigation. Furthermore, a wide variability of morbific microorganisms has been stated to be existing in these organic wastes. (Sonawane et. al., 2010). No significant study was made in the field of solid waste microflora in the Aurangabad City (AMC) study area. So, we were interested to investigate the microorganisms present in sewage wastes and to find out their applications. (Mohapatra, 2006). The sewage waste generated in urban usually said that municipal sewage waste (MSW). 27.6% of India's population resides in urban areas (census 2011). It is predicted 45% reside in cities by 2021. In India, waste quantity increasedfrom 45 million tons in 2011 to 70 million tons in 2021. (Kumar and Gaekwad, 2004). Aurangabad city generates large amounts of solid waste andsewage which is poorly disposed and untreated so, there is an instantaneous requirement for intended scientific integrated solid waste and sewage management for the city. Earlier studiesshowed that on average, each person in urban areas produces half a kilogram of garbage eachdayHaq et. al., 1999. According to EPA in 1989, only 20 % of this Municipal Solid Waste (MSW) is beingreprocessed, while 70% goes into landfills and 10% is incinerated. 1982;Blight and Mbande, 1996.Every singledayhugeamountsofsewagewastematerials are produced in all municipalities of India. In urban areas, solid and the extreme organic content of sewage effluent is between 65 and 80%. Along with population increase and rising per capita GNP, India's metropolitan areas are producing more solid garbage. Only (AMC) AurangabadCity Municipal Corporation (AMC). 10.05 million inhabitants produce about 3000 tonnes of rubbish every day. In the Aurangabad city region, daily rubbish generation per person ranges from 0.35 kg to 0.4 kilogramme. The recommended structure effectively collects the entire amount of garbage produced. About 10-15% of waste is recycled formally, while 35–50% is self-disposed of or illegally dumped rubbish. As a result, given the right circumstances, this degradable fraction may be combined with another substance to create soil conditioners and biofertilizers that would be beneficial. as per Parr and Hornick, 1992.The five main categories that make up the soil's microbial population include actinomycetes, fungus, algae, and protozoa. Among these groups, bacteria are the most prevalent and crucial for digesting trash, according to Sultana (1997). Bacteria consume waste products for their own metabolism, and as a result, they create some straightforward and practical mixes that are crucial for the health of the soil, plant growth, and the overall maintenance of the natural ecosystem's delicate balance. Composting is the controlled biodegradation or conversion of organic material, typically under aerobic circumstances, through which a substance is changed into a product that is stable and soil-like material known as manure. The number of microorganisms along with rodents and creatures play a vigorous character for the sewagewastedeprivation. The most significant part is played by bacteria; hence it is possible to use efficient microorganisms for the deliberate decomposition of solid organic waste. Given the crucial role that garbage decomposition plays, this investigation was conducted to create a repeatable process and search for more active decomposer bacteria that could effectively and efficiently break down organic wastes and produce components that are beneficial for plant sustenance.Theisolation and characteristics of solid waste vary from place to place; factors that influence the quantity and composition are the average income level, sources, population, social behaviour, climate, and the market for waste materials. Similar studies have been carried out by

various worker i.e.Haq, et. al., 1999; Joerger, et. al., 2009; Ramesh and Mathivanan, 2009; Sultana, 1997; Zaved, et. al., 2008 and Chetan, et. al., 2017.

Material and Methods:-

Study Area:

Aurangabad is an A grade municipal corporation and capital of Marathwada located at N19°53'47"–E75°23'54" of Maharashtra state. The city is bounded by mountains on all directions, and which is titled "The City of Gates" and the strong presence of these can be felt as one drives through the city. Aurangabad is the tourism capital of Maharashtra and is the fifth largest city in Maharashtra. It has an average rainfall of 756.6 mm and maximum and minimum temperatures of the city are 42.6^0C and 8.1^0C respectively.

Sample Collection:

An aggregate of 09 waste samples were collected05 from waste transfer site of Aurangabad Municipal Corporation (AMC) area and rest 5 from Industrial zone, landfill site of Naregaon of Aurangabad. Soil blended with waste was tested and gathered in sterile zip-lock plastic keeping up aseptic conditions, put at 4^0C and stamped as requirement be to their source and area. All the microorganism cultures were maintained at 4^0C in nutrient agar wholly the cultures were sub-cultured at 15to 20 days interval time.Ninesamplessewage waste werecollectedduringJanuary 2021 to February 2023fromNinedifferentareasofUrban and industrial regionsofAurangabad city area stored at 4^0C.and marked according to their source and location as shown in table 1.

Table 1:- Showing source and location of Sewage Sample collected in AMC area.

Sr. No.	Strain Code	Location
1	S1	Solid Waste Collection from Housing Colonies in AMC Area
2	S2	Solid Waste in Aurangabad City Area Dump (Garbage, behind Ghati Hospital
3	S3	Soil surface, Salim Ali lake side ofDelhi Gate, Aurangabad
4	S4	Transportation of Solid Waste in AMC Area Wet soil, drainsideofNaregaon AreaAurangabad
5	S5	Solid Waste Dump Sites in AMC Areadrainside garbage, Aurangabad
6	S6	Soilsurface, Segregation of Waste and Recycled items in AMC Area, Aurangabad
7	S7	Waste Encroached Road in Chikalthana Industrial Area wet soil of drain
8	S8	Housing Colony Waste Dumping Sites in Waluj Industrial Area wet soil ofdrain.
9	S9	Refuse, slaughterhouse, Padegaon Area, Aurangabad

Three bacterial samples such S1 to S3 showed better growth on theirfavorablemedium.According to Holt, 1984 and Forbes, 2007, and as previously mentioned by Nandi, 2016, the isolated bacteria were characterised using phenotypic approaches, such as colony morphology study, gram-staining and biochemical assays, including sugar fermentation for identification. Five antibiotics were tested on isolated bacteria by Hi-Media in India: gentamicin GEN, 30 g/disc, 30 g/disc of chloramphenicol C, and 10 g/disc of ampicillin AMP., methicillin MET; 5 µg/disc and piperacillin PI: 100 µg/disc, following disc diffusion Bauer, 1966. The results, in terms of zone diameter of the inhibition (ZDI) values of the test antibiotics,wereinterpretedfollowingtheguidelinesoftheClinicalandLaboratoryStandards InstituteChatterjee, 2010. Previous investigation groups have stated on this unattractive trend in the literature (Ahsan 1999; Agarwal 2005; Bandela et. al. 2010; Jha et. al. 2011; Ezeah and Roberts 2012; Kadafa et. al. 2013; Butu and Mshelia 2014; Uwadiegu and Iyi 2014; Thorat and Chavan 2021).Sewage waste sites are not supposed to be located very near to residential areas. In AMC area, waste dump sites which is are at randomdistributed very close to residences and public buildings. Site S_4 and S_8 gives a typical picture of such waste dump sites in Naregaon site in one of the Government reserved areas within the Aurangabad city municipal corporation area (AMC).

Isolation of microorganism:

The samples had been taken from metropolitan sewage and community sludge. Isolation of these microorganisms until get single colony had been completed by using serial dilution method and streaking method 26 agar plate were prepared aseptically. Afterward agar plate was completed, the fast growing of bacteria plate was taken. The diverse shape of microbes on the plate was selected by using aseptic technique.The selective bacteria on the agar plate were streaked. Plate was divided into 4 parts. The streak agar plate is sealed and kept in 30°C incubator for growing. After 24 hours, purification of bacteria was done using by another spread plate technique and incubation. Further that, from the earlier plate, gram staining was done. Samples was observed under microscope and characterized based on

Chetan, et. al., 2017. Identification of microorganism,biochemical test was performed by standard procedure based on Bergey's manual. For the identification of these microorganisms from municipal sewage, several biochemical identification methods such as gram stain, spore forming, strict anaerobes, starch hydrolysis, Voges-Proskauer and swollen cell test had been used. There are numerous biochemical identification systems completed of municipal sludge with colourdifferenceofthetestbacteriumwasdetected.

Resultsanddiscussion:-

The development of bacteria is influenced by several physiochemical factors, including the media, pH, temperature, incubation time, carbon source, etc. Microorganisms can flourish in a variety of humidity conditions. The range of moisture content of the samples that were obtained for the current investigation initially varied from 20.10 to 70.20%. The Aurangabad city municipal area and industrial area samples revealed the determined moisture content (70.20%) whereas the BCSS (2) sample revealed the minimal humidity content (25.09%). Different soils' bacterial populations are closely correlated with their relative humidity. The highest bacterial densities are found in areas with high moisture content, and aerobic bacterial activity is typically best when soil moisture retention capacity is between 45 and 80% of the soil moisture holdingcapacity. The study suggests that in order to protect human health and the environment from waste concerns, beneficial microorganisms should be segregated from the surrounding environment for safe bioconversion of organic waste. The established process of waste degradation as revealed in this investigation is believed to be both appropriate and effective. The goal of the study was to determine how sewage, decomposed waste, and bacterial suspension affected biomass output.

There has been an acceleration in the emergence and dissemination of multiple antibiotic resistant (MAR) bacteria due to the increasing and careless use of antibiotics in clinical practices, veterinary medicine, and agricultural practices, which is limiting the efficacy of the currently available antibiotics in treating human diseases caused by bacterial infections globally. Li, 2006. Obviously, the antibiotic resistances are not narrow inclinical settings, rather reported in agricultural as well as variousenvironmental settings, and foods(Penki, et. al., 2022). Previously, we have reportedtheisolationofpotentiallypathogenicbacteriafromtheriverine as well as municipal sewage wastewater receiving pollutedeffluentsin Aurangabad City Municipal Corporation area, Maharashtra, IndiaSonawane and Thorat, 2010. A totalof09 sewage i.e. bacteriaisolated are:S1,S2,S3,S4,S5,S6,S7,S8 and S9shown differentmorphologicalattributesoftheircolonies developed on nutrient agar plates as shown in Figure 2. Three of the isolated bacteria in Figure 2 (S4, S5, and S6) were gram-negative rods, while the remaining six isolates were either gram-positive rods (n = 10; S1, S2, S3, S7, S8 and S9) or gram-positive cocci (n = 1; S7). Tables 2 and 3 show the results of biochemical and sugar fermentation tests conducted on the isolated bacteria. Table 4 shows the microorganisms that have been identified after being characterised phenotypically. The occurrence of bacterial contamination of natural water resources with various microorganisms has been recorded. Table 5 shows the MAR indices and antibiotic resistance phenotypes of the isolated bacteria. According to Pasalari et al.'s 2019 research, Pseudomonas aeruginosa, Escherichia coli, and other gram-negative bacteria were successfully isolated from the fishpond. It showed resistance phenotypes for tetracycline erythromycin, cefuroxime tetracycline erythromycin, and cefuroxime tetracycline erythromycin ciprofloxacin in Pseudomonas aeruginosa, Escherichia coli, and Salmonella typhi, respectively. The bacterial isolates in the current study displayed resistance to at least one of the tested antibiotics; S2 strain had the lowest level of resistance to a single antibiotic (MET; MAR index: 0.2), while S1 strain had the highest level of resistance to four antibiotics (AMP-GEN-MET-PI; MAR index: 0.8). Six of the nine isolated bacteria displayed MAR phenotypes with resistance to two or more antibiotics, with MAR indices ranging from 0.5 to 0.7; in contrast, five isolates with resistance to two antibiotics had MAR indices of 0.4, as shown in Table 5. The S1 strain to chloramphenicol and the S2 strain to gentamicin both showed intermediate susceptibility to these two antibiotics. And for S4 and S9strains to piperacillin. Penki and Rout (2021) highlighted worry about how the majority of bacterial isolates have MAR indices greater than 0.2 due to excessive antibiotic loads in natural water supplies. The immediate study, where the MAR indices for the microbial isolates ranged from 0.2 to 0.8, recommended their isolated microbe's suggestion with niches having high levels of antibiotic contamination as well as the "human fecal source of origin" for most of the isolates in accordance with the measures stated previously (Tembekar, 2005 and Kaneene, 2007). in the AMC area.

Table 2:- Showing Biochemical test results for bacteria isolated from sewagesamples.

Straincode	Biochemicaltests							
	TSI	Ci-trate	In-dole	Cata-lase	Oxi-dase	MR	VP	DN-ase

S1	Y/Y	-	-	+	-	-	+	+
S2	Y/Y	+	-	+	+	-	+	-
S3	Y/Y	+	-	+	+	-	+	-
S4	Y/Y	+	-	+	-	+	-	-
S5	P/Y	-	-	+	+	-	-	+
S6	Y/Y	-	-	+	+	-	-	+
S7	Y/Y	-	-	+	+	+	-	-
S8	P/P	+	-	+	+	-	-	-
S9	Y/Y	-	-	+	+	-	-	-

Note: MR:Methylred;VP:Voges-Proskaur;P:Pink;Y:Yellow;-:Negative; +:Positive;TSI:Triplesugariron.

Table3:- Showing Sugarfermentationtestresultsforbacteriaisolatedfromsewagesamples.

Straincode	Sugars				
	Sorbitol	**Sucrose**	**Lactose**	**Maltose**	**Mannitol**
S1	+	+	+	+	+
S2	+	+	W	-	+
S3	-	W	-	-	-
S4	+	+	-	-	W
S5	-	-	-	-	-
S6	+	+	+	+	+
S7	+	+	W	+	+
S8	-	-	-	-	-
S9	-	-	-	-	-

Note: W:Weaklypositive;-:Negative;+:Positive.

Table4:- Showing Identityofbacteriaisolatedfromsewagesamples.

Straincode	Bacterialidentity
S1	Corynebacteriumxerosis
S2	Bacilluscereus
S3	Bacillussubtilis
S4	Bacillusmegaterium
S5	Chryseobacteriumindologenes
S6	Micrococcusluteus
S7	Bacilluscirculans
S8	Pseudomonasaeruginosa
S9	Bacillusindicus

Table5:- Showing AntibioticresistanceprofilesandMARindicesfortheisolatedsewagebacteria.

IsolatedBacteria	Antibioticresistance Profile					MAR index
	AMP	**C**	**GEN**	**MET**	**PI**	
S1:C.xerosis	R	S	S	R	S	0.4
S2:B.cereus	R	S	S	R	R	0.6
S3:B.subtilis	R	S	S	R	R	0.6
S4:B.megaterium	R	S	S	R	S	0.4
S5: C.indologenes	R	S	S	R	R	0.6
S6:M.luteus	R	S	S	R	S	0.4
S7:B.circulans	R	S	S	R	S	0.4
S8:P.aeruginosa	R	R	S	R	S	0.6
S9:B.indicus	S	S	S	R	S	0.2

Note: (n=9) AMP:ampicillin;C:chloramphenicol;GEN:gentamicin;MET:methicillin;PI: piperacillin.

Figure 1: Showing colony characteristics of bacteria isolated from Sewage samples.

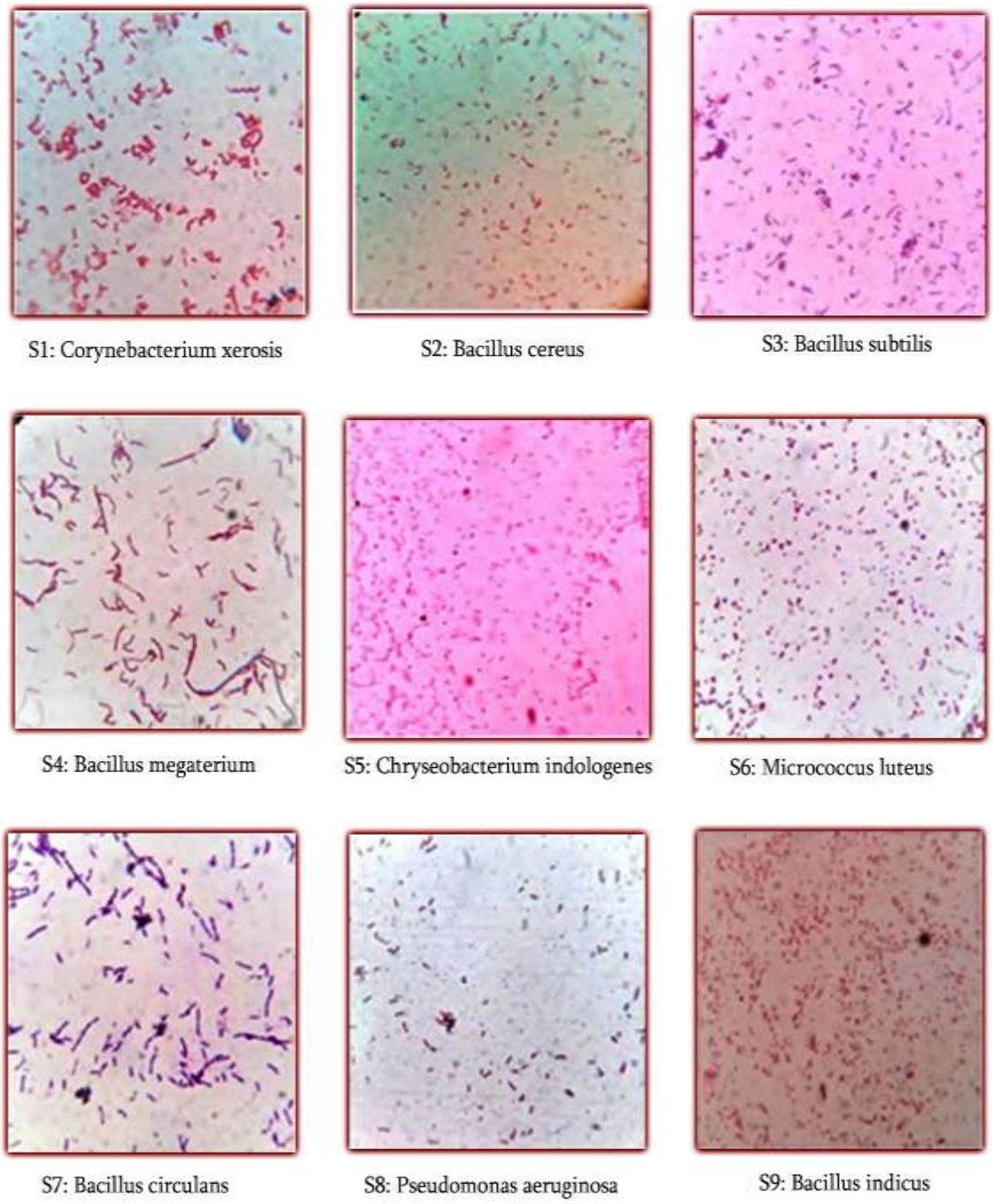

Figure 2: Showing gram staining property of bacteria isolated from sewage samples.

Conclusions:-

Municipal sewage is a combination of many substrates, making it the perfect enrichment medium for the development of a wide adaptation of microorganisms. The metabolic activity of the microbes in this environment concerns in the making of various enzymes and bioactive mixturesallied to other conservational conditions. It is vital to realize the waste-derived microorganisms in ecological terms and as a biotechnology source. Our current research has clearly revealed that sewage, as shown in the study, supports the growth of gram-positive rods, cocci, and gram-negative rods as well. The diversity of gram-positive bacteria was higher than that of gram-negative bacteria. The isolated bacteria were capable of infecting humans and had a range of MAR indices and antibiotic resistances. To combat the bacterial multiple antibiotic resistances, there is an urgent and imperative need to maintain regular vigilance of such environmental bacteria of clinical relevance and to prepare effective Indian guidelines for the prudent use of antibiotics that can also serve as a good substitute in industries.

Reference:-

1. Agarwal, A., Singhmar, A., Kulshrestha, M., Mittal, A.K., (2005). Municipal solid waste recycling and associated markets in Delhi, India. Journal of Resources, Conservation and Recycling 44 (1), 73–90.
2. Ahsan, N., (1999). Solid waste management plan for Indian megacities. Indian Journal of Environmental Protection 19 (2), 90–95.
3. Ajayi A. O., (2014):"Bacteriological study of pond water for aqua-culture purposes". Journal of Food, Agriculture and Environment 12.2 1260-1265.
4. Amalraj, S (2006): Introduction to Environmental Science and Technology, Laxmi publication (pp 61-66), New Delhi.
5. BaqueroF.,(2008):"Antibioticsandantibioticresistanceinwaterenvironments". Current Opinion in Biotechnology 19 260-265.
6. Blight, G. E. and Mbande, C. M. (1996):Some problems of waste management in developingcountries,JournalofSolidWasteTechnologyandManagement,23(1),19–27.
7. Bundela, P. S., Gautam, S.P., Pandey, A.K., Awasthi, M.K., and Sarsaiya S., (2010). Municipal solid waste management in Indian cities. Int. J. Environ. Sci. 1 (4), 591–605.
8. Butu A. W., Mshelia S. S. (2014).Municipal Solid Waste Disposal and Environmental Issues in Kano Metropolis, Nigeria. British Journal of Environmental Sciences, 2(1): 1-16.
9. Chatterjee, R., (2010). Municipal solid waste management in Kohima city - India. Iran. J. Environ. Health Sci. Eng. 7 (2), 173–180.
10. Chetan D. M, Raghavendra H. L, Prithviraj H.K. (2017): Isolation and Characterization of Bacteria from Solid Waste. International Journal of Research and Scientific Innovation (IJRSI) | Volume IV, Issue V, May 2017, Pp 63-68. ISSN 2321–2705. J, 8 (2), 44.
11. Ezeah C, Roberts C. L., (2012). Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. Journal of environmental management, 103: 9-14.
12. Haq R, Zaidi SK, Shakoori AR, (1999): Cadmium resistant Enterobacter clacae and Klebsiella sp isolated from industrial effluents and their possible role in cadmium detoxification. World Journal of Microbiology and biotechnology, 1999:15:2: 283-290.
13. Ingrassia, L.P., Lu, X., Ferrotti, G. and Canestrari, F. (2019): Chemical and rheological investigation on the short- and long-term aging properties of bio-binders for road pavements. Constr. Build. Mater., 217: 518-529.https://doi.org/10.1016/j.conbuildmat.2019.05.103
14. Ingrassia, L.P., Lu, X., Ferrotti, G., Conti, C. and Canestrari, F. (2020): Investigating the "circular propensity" of road bio-binders: Effectiveness in hot recycling of reclaimed asphalt and recyclability potential. J. Clean. Prod., 255: 120193.
15. Jha, A. K., Singh, S. K., Singh, G. P., and Gupta, P. K., (2011). Sustainable municipal solid waste management in low-income group of cities: a review. Int. Soc. Trop. Ecol. 52 (1), 123–131.
16. Joerger RD, Sabesan S, Visioli D, Urian D, Joerger MC, (2009): Antimicrobial activity of chitosan attached to ethylene copolymer films. Packaging Technology and Science, 2009: 22:3: 125-138.
17. Kadafa A.Y., Latifa A, Abdullahi HS and Suleiman W. A, (2013). Comparative Assessment of the municipal Solid Waste Management Services. Nature and Science, 11(6): 154-164.
18. Kaneene B. J. (2007):"Considerations when using discrimination function analysis of antimicrobial resistance profiles to identify sources of faecal contamination of surface water in Michigan". Applied and Environmental Microbiology 73 2878-2890.
19. Krumperman P. H.,(1983): "Multiple antibiotic resistance indexing ofEscherichia coli to identify high-risk

sources of fecal contaminationoffoods".AppliedandEnvironmentalMicrobiology46.1 165-170.
20. Kumar S and Gaekwad SA, (2004): Muncipal solid waste management in Indian urban centers: An approach for betterment" urban development debates in New millennium, Edited by K. R. Gupta, Atlantic publishers and distributor, New delhi pp 100-111.
21. Mohapatra P.K. (2006): Environmental Biotechnology. I. K. International Pvt. Ltd, New Delhi, 53 – 55.
22. Mukhopadhyay C., (2012): "Microbial quality of well water fromrural and urban households in Karnataka, India: a cross-sectional study". Journal of Infection and Public Health 5 257-262.
23. Mulamattathil., (2014):"Isolationofenvironmentalbacteriafrom surface and drinking water in Mafikeng, South Africa,andcharacterizationusingtheirantibioticresistanceprofiles".Journalof Pathogens 1-11.
24. Njoku., (2015):"Aninvestigationofthemicrobiologicalandphysico-chemical profile of some fishpond water within theNiger Delta region of Nigeria". African Journal of Food Service9.3 155-162.
25. Parr, J. F. and Hornick, S. B., (1992):Utilization of municipal wastes, In: Soil MicrobialEcology: Applications in agricultural and environmental management,pp. 545–559. F.B.Metting(ed.)MarcelDekker,Inc.,NewYork,U.S.A.
26. Pasalari, H., Nodehi, R.N., Mahvi, A.H., Yaghmaeian, K. and Charrahi, Z. (2019): Landfill site selection using a hybrid system of AHP-Fuzzy in GIS environment: A case study in Shiraz city, Iran. Methods X, 6: 1454-1466. https://doi.org/10.1016/j.mex.2019.06.009.
27. Penki, R. and Rout, S.K. 2021. Next-generation bitumen: a review on challenges and recent developments in bio-bitumen preparation and usage. Biomass Conv. Bioref., 11: 80. https://doi.org/10.1007/s13399-021-01803-4.
28. Penki, R., Basina, S.S. and Tanniru, S.R. 2022. Application of geographical information system-based analytical hierarchy process modelling for flood susceptibility mapping of Krishna District in Andhra Pradesh. Biomass Conv. Bioref., 16: 71. https://doi.org/10.21203/rs.3.rs-1399020/v1.
29. Poonia., (2014): "Antibiotic susceptibility profile of bacteria isolated from natural sources of water from rural areas of EastSikkim". Indian Journal of Community Medicine 39. 3 156-160.
30. Ramesh S, Mathivanan N, (2009): Screening of marine actinomycetes isolated from the Bay of Bengal, India for antimicrobial activity and industrial enzymes. World Journal of Microbiology and biotechnology, 2009: 25:12: 2103-2111.
31. Sidhu S.,(2016): "Bacteriological analysis of the drinking waterfrom different schools in Northern India: a concern in developing countries". International Journal of Medical Resarch andReview4. 4. 630-634.
32. Sonawane Ramnath K. and Sanjaykumar R. Thorat (2010): "Studies on Municipal Solid waste management in Jalgaon city of Maharashtra: A case study", Bull. of Envi. Sci. Vol. XXVIII (1st Issue), Pp. 1-8 ISSN: 0971-1732.
33. Sonawane Ramnath K., Anand C. Sonawane, and Sanjaykumar R. Thorat (2010): "Technology to Develop Manure from Municipal Solid Waste: Wealth from Waste', J. of Biotechnology and Bioinformatics. Vol. 1 (2) Pp. 215-221. ISSN: 0974-9438.
34. Sultana S, (1997): Isolation of cellulolytic microorganisms and their activities. M. Phil. Thesis Institute of Biological Science, University of Rajshahi Bangladesh, Bangladesh, 1997.
35. Tambekar D. H. (2005):"MAR indexing to discriminate the source of faecal contamination in drinking water". Nature Environment and Pollution Technology 4 525-528.
36. Taneja N. (2019): "Antimicrobial resistance in the environment:the Indian scenario". Indian Journal of Medical Research 149 119-128.
37. Thorat A. S. and Chavan T. P., (2021): Status of Urban Solid Waste Management in Aurangabad Town of Maharashtra Region. Aayushi International Interdisciplinary Research Journal (AIIRJ), Vol. 8(1) I.F. 7.149 ISSN: 2349-638x. Pp. 1-9.
38. Uwadiegu B. O., Iyi EA (2014). An Evaluation of the Operational Efficiency of a Public Agency: A Case Study of Enugu State Waste Management Authority (Eswama) In Enugu City, Nigeria. British Journal of Environmental Sciences, 2(2): 27-34.
39. Van BoeckelTP.,(2014):"Global antibiotic consumption 2000 to2010: an analysis of national pharmaceutical sales data". TheLancetInfectiousDiseases14, 742-750.
40. Zaved HK, Rahman MM, Rahman MM, Rahman A, Arafat SMY, (2008): Isolation and characterization of effective bacteria for solid waste degradation for organic manure, KMITL Sci Tech J, 2008: 8:2: 844-855.
41. Zhang XX., (2009): "Antibiotic resistance genes in water environment". Applied Microbiology and Biotechnology 82 397-414.