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Beach litter survey of selected beaches of coromondel coast of Tamil Nadu, India

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ABSTRACT

The beach litter survey of the selected beaches of Tamilnadu viz. Marina, (lat 13°055'N and long 80°28'E), Besant nagar (lat 12°99'N, long 80°27E) and Thiruvanmiyur (lat 12°97'N and long 80°26´E) were done in the year 2014. Beach litter survey was done mainly to quantify as well as to know the distribution pattern of different types of litter in all the selected beaches surveyed. The different types of litters surveyed in the year 2014 from Jan-Dec includes nylon/ HDP ropes/fishnet pieces (A), plastics covers, sachets, containers of creams, oil, ointments(B), chappals, foot wear (other than leather items)(C), glass bottles, electric bulbs, CFL bulbs (source of Hg) (D), waste (TV, Computer hard- wares, mobile phone handsets charges)(E) and Thermo col, PUF insulators of AC/Fridge, Styrofoam, etc. (F). Among the total litter distribution item C, chappals, footwear (other than leather items) is the highest (4000g/m^2) followed by item B, plastics covers, sachets containers of creams, ointments, oil, (2525 g/m^2), item F, thermocol, PUF insulators of AC/Fridge, stryrofoam, (1310g/m^2), item D, glass bottles, electric bulbs, CFL bulbs (sources of Hg), (1125g/m^2) and item A, nylon, HDP ropes and fishnet pieces, 1075 g/m^2. In Marina Beach, in post monsoon season (Jan'14 to Mar'14) the item C is more than in A followed by B,D,F and E in summer season(Apr'14 to June'14) the litter distribution is more in C followed by F, B, D, A & E. In pre monsoon season (July'14 to Sep'14) the item B is more followed by C, F, A, D and E in monsoon season, (Oct' 14 to Dec'14) the item B is followed by F,C, A, E and D. In Besant nagar beach in post monsoon season, (Jan'14 to Mar'14) the item C is more followed by D, A, B, F and E in summer season (April' 14 to June'14) the item C is more followed by B,F,A,D and E in pre monsoon season, the item B is more followed by C,F,A,D and E in monsoon season, the item F is followed by B, A, C, D and E. In Thiruvanmiyur beach in post monsoon season(Jan'14 to Mar'14) the item C is more followed by B, A, F, D and E, in summer season, (Apr'14 to June' 14) the item B is more followed by C,F,A,D and E in pre monsoon season, (July'14 to Sep'14) the item B is more followed by F,A,D,C and E in monsoon season, (Oct'14 to Dec'14) the item D is more followed by B,C,F, A and E. In marina beach, the PCA analysis of the beach litter for 12 consecutive months showed that the 2 components extracted had a variance of 49.02% with an eigen value of 2.45 and 25.63%, cumulative variance of 74.65% with an eigen value of 1.28. In Besant nagar beach, the PCA analysis showed that the 2 components extracted had a variance of 43.51% with an eigen value of 2.18 and 32.73% with an eigen value of 1.64 and the cumulative variance of 76.23%. In Thiruvanmiyur beach, the 2 PCA components extracted had a variance of 55.51% with an eigen value of 2.78 and 30.58% with an eigen value of 1.53 and the cumulative variance of 86.09%.

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Key words : *Beach litter classification, Spatial and temporal distribution, Seasonal variation, Survey*

Introduction

Beach surveys are done for spatial and temporal distribution of litter. The survey along the beaches are done to know the different types of litter and their quantity per square meter. The marine debris quantification is a must since the debris may go into the ocean and choke the marine organisms and the worst part of it is the plastics getting into the sea from the seashore and affects the healthy nature of the ocean marine living organisms. Hence a study was undertaken in three different beaches of Chennai, viz. Marina beach, Besant nagar beach and Thiruvanmiyur beach. These marine debris are as a result of recreational activities of the human beings and certain religious activities done on the beach and leaving the debris behind. This goes into the sea since it is not a practice to even touch those items. These debris can be reduced or eradicated completely by giving proper education in the schools/ colleges and public awareness campaigns conducted then and there to keep the environment clean. The Marine beach, Besant nagar is 12km length and Thiruvanmiyur beach is 13kms along the Chennai coast. Marina beach is the longest beach in India lies on the eastern side of the city, lining bay of Bengal, Besant nagar beach also lies in the eastern coast of Tamilnadu, Thiruvanmiyur beach is 3km south of Adyar.

Materials and Methods

The beach litter survey was done in three selected beaches of Tamilnadu, Marina beach, Besant nagar beach and Thiruvanmiyur beach in $1m^2$ area by random surveying. Using rope and iron poles a boundary of 1 m^2 was made and the different types of litter viz. A,B,C,D,E and F were collected manually and put in labeled separate polyethylene covers and stored in laboratory for further weighing in an electronic balance of accuracy, 0.001g. The mud coated litter was either dry cleaned with a tissue paper or wet cleaned under the tap water and weighed separately in electronic balance.

Results and Discussion

In Marina beach, the PCA analysis of the beach litter for 12 consecutive months showed that the 2 components extracted had a variance of 49.02% and 25.63%, cumulative variance of 74.65%. The component A had a 49.02% variance with an eigen value of 2.45, the component B had a 25.63% variance with an eigen value of 1.28, the component C had 14.59% variance with an eigen value of 0.73, the component D had 8.74% variance with an eigen value of 0.44% the component F had 2.02% variance with an eigen value of 0.10. The component C, has the highest contributor to the total litter followed by item D, item A item B and then item F, on the component and the negative contribution was by item A and item C and the positive contribution was by item F, followed by item B and item D. The total weight of Item A is 10.71% out of the grand total of all the items collected for 12 months in a year. The total weight of Item B is 25.16% out of the grand total of all the items collected for 12 months in a year. The total weight of Item C is 39.86% out of the grand total of all the items collected for 12 months in a year. The total weight of Item D is 11.21% out of the grand total of all the items collected for 12 months in a year. The total weight of Item F is 13.05% out of the grand total of all the items collected for 12 months in a year. The total weight is more in item C, 39.86% than in items, F, D&A. In Besant nagar beach, the PCA analysis showed that the 2 components extracted had a variance of 43.51% and 32.73% and the cumulative variance of 76.23%. The component A had a 43.05% variance with an eigen value of 2.18, the second component B had a variance and 32.73% with an eigen value of 1.64% the third component C had a 10.21% variance with a eigen value of 0.51, the fourth component D had a 8.87% of variance with an eigen value of 0.44, the sixth component F had a 4.69% variance with an eigen value of 0.23. In the first component, the major contributor was item A, 0.90, followed by item C, D and item F, the negative contributor is item

B. In the second component, the item A and item D does not contribute to the total litter, the contributors are item B followed by item F and item C. The total weight of Item A is 9.26% out of the grand total of all the items collected for 12 months in a year. The total weight of Item B is 27.13% out of the grand total of all the items collected for 12 months in a year. The total weight of Item C is 33.71% out of the grand total of all the items collected for 12 months in a year. The total weight of Item D is 10.34% out of

the grand total of all the items collected for 12 months in a year. The total weight of Item F is 19.56% out of the grand total of all the items collected for 12 months in a year. In Besant nagar beach, the total weight is more in the item C, 33.71% followed by item B,F,D and A. In Thiruvanmiyur beach, the 2 PCA components extracted had a variance of 55.51% and 30.58% and the cumulative variance of 86.09%. The component A had a 55.51% variance with an eigen value of 2.78, the component B had a 30.58% variance with an eigen value of 1.53, the component C had a 8.34% variance with an eigen value of 0.42, the component D had a 4.12% variance with an eigen value of 0.21, the component F had a 1.45 variance with an eigen value of 0.07. In the first component, the major contributor was item B, 0.97 followed by item D, item F, item C and item A. In the second component, the major contributor was item A followed by item C and item D, the negative contribution was by item F and D. The total weight of Item A is 11.78% out of the grand total of all the items collected for 12 months in a year. The total weight of Item B is 32.01% out of the grand total of all the items collected for 12 months in a year. The total weight of Item C is 19.99% out of the grand total of all the items collected for 12 months in a year. The total weight of Item D is 20.16% out of the grand total of all the items collected for 12 months in a year. The total weight of Item F is 16.06% out of the grand total of all the items collected for 12 months in a year. Among the 3 beaches tested, the Thiruvanmiyur beach was the best having an eigen value of 2.78 followed by Marine beach with an eigen value of 2.45 then Besant nagar beach with an eigen value of 2.18. The first component in Marina beach is highly correlated with the item C and the second component is highly correlated with the item F. The first component in Besant nagar beach is highly correlated with the item A and the second component is highly correlated with the item B. The first component in Thiruvanmiyur beach is highly correlated with the item B and the second component is highly correlated with the item A. The items C, F, A and B are important since they are correlated in the three beaches selected. Highly costing beach cleaning has the aim of keeping beaches attractive to tourists (Balance *et al.,* 2000 and Silver Iniguez and Fischer, 2003).

The threats to marine life are primarily mechanical due to ingestion of plastic debris and entanglement in packaging bands, synthetic ropes and lines or drift nets (Laist, 1987, 1997, Quayle, 1992). Plastics floating at sea may acquire a fauna of various encrusting organisms such as bacteria, diatoms, algae, barnacles, hydroids and tunicates (Carpenter *et al.,* 1972; Carpenter and Smith, 1972; Minchim, 1996; Clark, 1997). Heavy metals or other contami- nants could be transferred to filter feeding organisms and other invertebrates, ultimately reaching higher trophic levels. (Gregory, 1996) A/c to Zitko (1993) low molecular weight compounds from polystyrene particles are leached by seawater and the fate and effects of such compounds on aquatic biota are not known. In fact, environmental education has been suggested as an efficient strategy for decreasing tourism related beach litter (Santosh, *Friedric*, 2003,

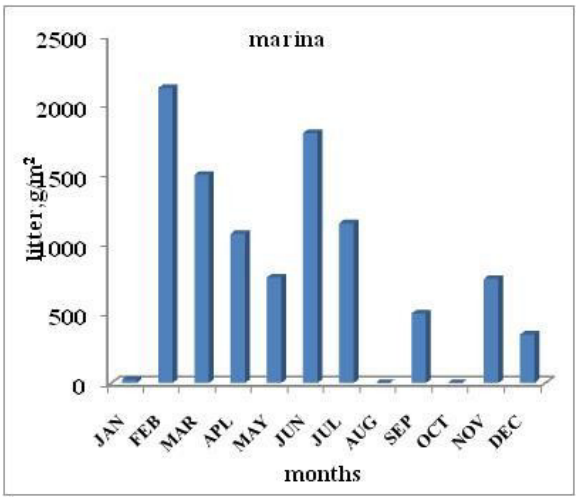

Fig. 1. Monthly litter distribution in Marina

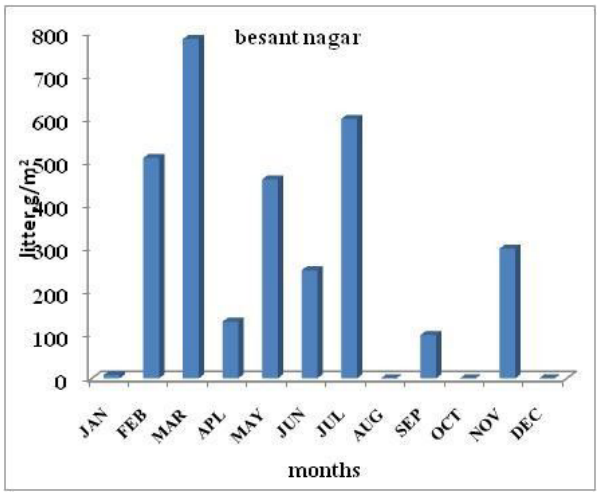

Fig. 2. Monthly litter distribution in Besant nagar beach beach

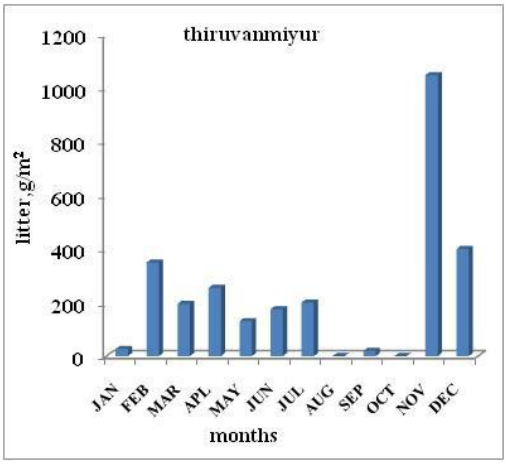

Fig. 3. Monthly litter distribution in Thiruvanmiyur beach

2003, Balance, *et al* , 2000, Caulton, Mocogni, 1987;

The correlation coefficient between Besant nagar beach and Marina beach is r=0.72, between Thiruvanmiyur and marina beach, r=0.24 and between Thiruvanmiyur and Besant nagar r=0.19. (3.2) Seasonal effect: In post monsoon season, the PCA analysis for the post monsoon season for all the three beaches tested, yield only one component with a variance of 75.51% with an eigen value of 3.78. The component A had 75.51% variance with an eigen value of 3.78, the component B had 15.17% variance with an eigen value of 0.76, the component C had 5.83% variance with an eigen value of 0.29, the component D had 3.22% variance with an eigen value of 0.16, the component F had 0.29% variance with an eigen value of 0.01. The one component extracted had a major contributor of item C followed by item A, B, D and E, The eigen value is highest in post monsoon season, 3.78. The total weight litter in Marina was Item A, 21.92%, item B, 15.75%, Item C 46.58%, item D, 13.70 %, item F, 2.06% out of the grand total of all the items collected for first three months in this year, the total weight of litter in Besant nagar was Item A, 22.26%, item B, 7.91%, Item C 30.16%, item D, 24.94%, item F, 6.52% out of the grand total of all the items collected for first Three months in this year, the total weight of litter in thiruvanmiyur was Item A, 21.85%, item B, 27.45%, Item C 29.72%, item D, 7.87%, item F, 13.11% out of the grand total of all the items collected for first three months in this year. In monsoon season, the plastics are great menace and most frequently used by people as snack food items are sold along the beach. The frequent visitors of the beach throw the used plastic snack covers, water bottle covers and plastic bottle lids. In post monsoon season and in summer season, the item C is more because of frequent visitors and the beach sand gravitational force which makes more force to be exerted during walking and the chappals gets torn and the visitors leave the chappal in the beach sand. Especially in summer season, the frequent visitors include school students. In Besant nagar, in monsoon season, the thermocol used in nets for floating purposes and identification is scattered more in the beaches, hence item F is more. In Thiruvanmiyur, in monsoon season, the liquor bottles are more, hence item D is more since most of the time beaches are considered for recreational purposes and full day work of the labourers category always go to liquor shops for their enjoyment for the full work. The cumulative variance in Thiruvanmiyur is more (ie) 86.09% followed by Besant nagar beach and then in Marina beach. The litter distribution among the categories A-F is more in Thiruvanmiyur than in besant nagar than in Marina beach. In summer season, the PCA analysis of summer season yield 2 components, 61.21% with an eigen value of 3.06 and second component with 21.07% variance with 1.06, the cumulative variance was 82.28. The component A had 61.21% with an eigen value of 3.06, the component B had 21.07% variance with an eigen value of 1.05, the component C had 12.52% variance with an eigen value of 0.63, the component D had 4.35% variance with an eigen value of 0.22, the component F had 0.85% variance with an eigen value of 0.04. In the first component for major contributor was item F, followed by item B, item D and item C. The item A did not much contribute to total litter. In the second component, the major contributor was item A followed by item F, item C and item B, item D did not contribute much to the total litter. In summer season, the total weight of litter in Marina was Item A, 2.06%, item B, 16.51%, Item C, 44.02%, item D, 16.51 %, item F, 20.91% out of the grand total of all the items collected for first three months in this year. the total weight of litter in Besant nagar was Item A, 0.12%, item B, 29.73%, Item C, 42.81%, item F, 27.35% out of the grand total of all the items collected for first three months in this year, the total weight of litter in Thiruvanmiyur was Item A, 17.86%, item B, 31.25%, Item C, 25.00%, item D, 3.571%, item F, 22.32% out of the grand total of all the items collected for first three months in this year. In pre-monsoon season, the PCA analysis yield 2 components, first component is 64.26% and the second component is 28.71%,

the cumulative variance is 92.97%. The component A had 64.26% variance with an eigen value of 3.21, the component B had 28.71% variance with 1.44, the component C had 5.35% variance with an eigen value of 0.27, the component D had 1.55% variance with an eigen value of 0.08, the component F had 0.13% variance with an eigen value of 0.01. In the first component, the major contributor is the item B, 0.99 to the total litter followed by item C, A, F and item D. In the second component, the items C and F did not contribute to the total litter and the contributors were items D, followed by item A and item B. In pre monsoon season the total weight of litter in marina was item B, 68.18%, item C, 13.64%, item F, 18.18% out of the grand total of all the items collected for first three months in this year, the total weight of litter in Besant nagar was Item A, 33.33%, item F, 66.67% out of the grand total of all the items collected for first three months in this year and the total weight of litter in Thiruvanmiyur was Item A, 6.90%, item B, 31.03%, item C, 17.24%, item D, 34.48%, item F, 10.35% out of the grand total of all the items collected for first three months in this year. In monsoon season, the PCA analysis yield, component having 64.14% variance with an eigen value of 2.57. The component B had 64.14% variance with an eigen value of 2.60, item C had 18.70 % variance with an eigen value of 0.75, item D had 15.58% variance with an eigen value of 0.62, item F had 1.58% variance with an eigen value of 0.06. In monsoon season the total weight of Marina was item B, 68.18%, item C, 13.64%, item F, 18.18% out of the grand total of all the items collected for first three months in this year, the total weight of litter in Besant nagar was item B, 33.33%, item F, 66.67% out of the grand total of all the items collected for first three months in this year, the total weight of litter in Thiruvanmiyur was item A, 6.90%, item B, 31.03%, item C, 17.24%, item D, 34.48%, item F, 10.35% out of the grand total of all the items collected for first three months in this year. In the extracted component, the major contributor is item B followed by item C, item F and item D. In post monsoon season, the first component is correlated to item A. In summer season, the first component is correlated to the item F the second component is correlated to the item A. In pre- monsoon season, the first component is correlated to the item B the second component is correlated to the item D. In monsoon season the first component is correlated to the item B. Hence the items A, F, B and D is important since these components are correlated. In post monsoon season, the correlation coefficient between Besant nagar and Marina is r=0.80, between Thiruvanmiyur and marina, r= 0.98, between Thiruvanmiyur and Besant nagar beach, r=0.66, in summer season, the correlation coefficient between Besant nagar and Marina, r=(-0.44) and is negative between Thiruvanmiyur and Marina is r=0.139, between Thiruvanmiyur and Besant nagar, r=(-0.95), in pre monsoon season, the correlation coefficient between Besant nagar and Marina is r=0.96, between Thiruvanmiyur and marina, r=0.94, between Thiruvanmiyur and Besant nagar, r=0.99, in monsoon season, the correlation coefficient between Besant nagar and Marina is r=0.89, between Thiruvanmiyur and Marina beach is r=0.99, between Thiruvanmiyur and Besant nagar beach, r= 0.93.

Sl. No.	ANOVA Source of variation	Post monsoon season SS	df	MS	F	P-val	F crit	s/ns
1	beaches	390541	5	78108.2	2.86	0.02	2.47	s ($p \leq 0.05$)
2	months	271612	2	135806	4.97	0.01	3.25	s($p \leq 0.05$)
3	beaches X months	222816	10	22281.6	0.81	0.61	2.10	ns($p \geq 0.05$)
4	within	981935	36	27276				
	Total	1866904	53					

S. No.	ANOVA Source of variation	Summer season SS	df	MS	F	P-val	F crit	s/ns
1	beaches	321371	5	64274.3	2.78	0.03	2.47	s($p \leq 0.05$)
2	months	25215.6	2	12607.8	0.54	0.58	3.25	s($p \leq 0.05$)
3	beaches X months	157001	10	15700.1	0.68	0.73	2.10	ns($p \geq 0.05$)
4	within	830934	36	23081.5				
	Total	1334522	53					

S. No.	ANOVA source of variation	Pre-monsoon season SS	df	MS	F	P-val	F crit	s/ns
1	beaches	108131	5	21626.3	3.43	0.01	2.47	s(p≤0.05)
2	months	110293	2	55146.3	8.75	0.00	3.25	s(p≤0.05)
3	beaches X months	119096	10	11909.6	1.89	0.07	2.10	s(p≤0.05)
4	within	226667	36	6296.3				
	Total	564187	53					

S. No.	ANOVA source of variation	Monsoon season SS	df	MS	F	P-val	F crit	s/ns
1	beaches	117639	5	23527.8	2.61	0.04	2.47	s(p≤0.05)
2	months	125833	2	62916.7	7.00	0.00	3.25	s(p≤0.05)
3	beaches X months	115278	10	11527.8	1.28	0.27	2.10	ns(p≥0.05)
4	within	323333	36	8981.48				
	Total	682083	53					

Spatial and Temporal Distribution

The two way anova for all the three beaches selected for consecutive 12 months tested were highly significant at 5% level of significance for the selected 3 beaches and 12 months and their interaction also were significant at the same 5% level (p≤0.05) Among the 12 months tested, the highest litter was in Feb'14 month in Marina beach followed by Dec'14 month, Sep'14, Nov'14, May'14,April'14, July'14, Mar'14 and June'14. The lowest litter was in June'14, 25g/m^2. In Besant nagar beach, the highest litter occurred in Mar'14 month, 785g/m^2 followed by Jul'14, Feb'14, May'14, Nov'14, June'14, April'14 and Sep'14. The lowest was 8g/m^2 in Sep'14 month. The highest month containing litter was Nov'14 followed by Dec'14, Feb'14, Apl' 14, July'14, Mar'14, Jun'14, May'14, Jan'14 and Sep'14. The lowest litter

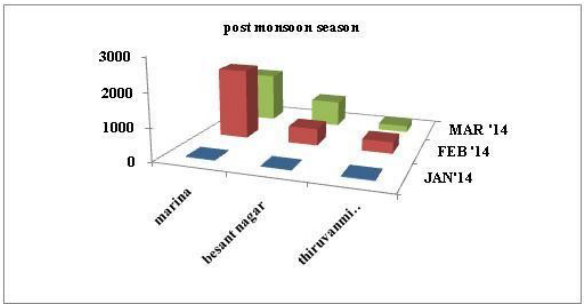

Fig. 4. Beach litter distribution in post monsoon

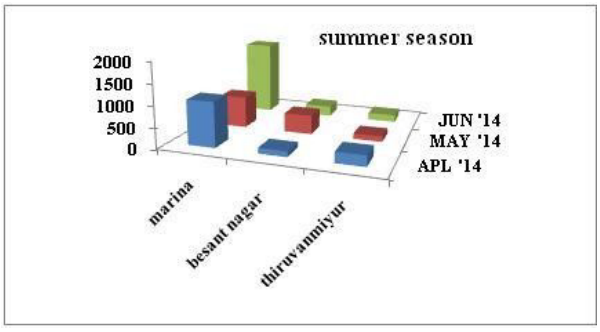

Fig. 5. Beach litter distribution in summer season season

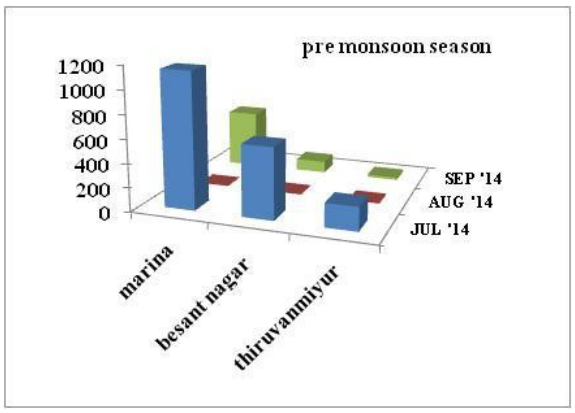

Fig. 6. Beach litter distribution in premonsoon

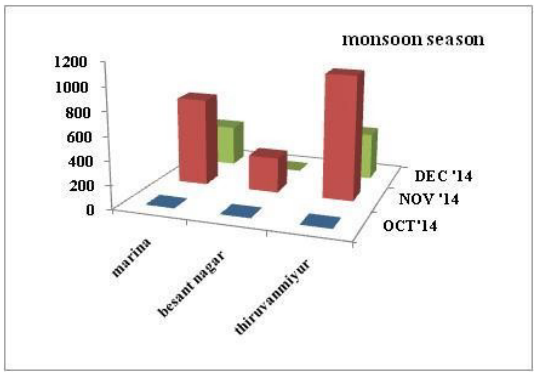

Fig. 7. Beach litter distribution in monsoon season season

was in Sep'14 month, 20g/m^2. In Thiruvanmiyur beach, the maximum of item A occurred in April'14 month, 100 g/m^2, the item B occurred in Nov'14 month, 300g/m^2, the item C occur red in Dec'14 month, the item D occurred in Nov'14 month, the item F occurred in Nov'14 month, In Besant nagar beach, the item A occurred most in Mar'14 month, 250g/m^2 the item B occurred most in Jul'14 month, 300g/m^2, the item C occurred most in Mar'14 month, 350g/m^2, the item D occurred most in Feb' 14 month, 200g/m^2, the item F occurred in Nov'14 month, 200g/m^2. In Marina beach, the item A occurred most in month, Feb'14. The item B occurred most in month Nov'14 month, 500g/m^2, the item C occurred most in the month, Feb'14 month, 900g/m^2, the item D occurred most in month, June'14 month, 600g/m^2 and item F occurred in June'14 month.

In all the 4 seasons, the selected three beaches and the months were significantly different at 5% level of significance, p≤0.05. The item Beach was individually significant at 5% level of significance and the item month was also significant and the interaction effect between month and beach was also significantly different at 5% level. The two way anova table shows the level of significance of both the variables tested for the study. The mean litter in marina beach in item A was 89.58g/m^2 ±45.17 with the coefficient of variation of 1.75% in item B was 210.42g/m^2 ± 43.90 with a cv of 72 in item c was 333.33g/m^2 ± 97.04, with the cv of 1.01%, in item D was 93.70g/m^2 ± 56.75 with the cv of 2.1% and in item F was 109.16g/m^2 ± 38.62 with a cv of 1.23%. The cv was calculated for all measurements as an indication of the extent of temporal variation of the litter distribution. Cv expresses the standard deviation of a set of values as a percentage of the average and is useful when comparing variability in datasets with different means. High cv represents high temporal variability. The mean litter in besant nagar beach was in item A, 1.42g/m^2 ± 0.68 with a cv of 1.66% in item B was 2.17g/m^2±0.41 with a cv of 65%, in item c the mean litter was 3.67g/m^2±0.96 with a cv of 91%, in item D the mean litter was 1.08g/m^2 ± 0.57 with a cv of 1.82%, in item F the mean litter was 2.17g/m^2±0.58 with a cv of 92%. The mean litter in Thiruvanmiyur in item A was 27.50g/m^2 ±12.02 with a cv of 1.51%, in item B was 74.75g/m^2 ±24.73 with cv of 1.15%, in item c was 46.67g/m^2±16.25 with the cv of 1.21% in item D was 47.08g/m^2±41.28 with cv of 3.04%, in item F was 37.50g/m^2 ±14.06 with cv of 1.30%. Including the three beaches tested in post monsoon season the item A mean litter was 243g/m^2 ±58.71 with a cv of 73%, in item B mean litter was 167g/m^2 ±36.13 with a cv of 65%, in item c the mean litter was 474g/m^2 ± 117.13 with a cv of 74% in item D the mean litter was 174g/m^2 ± 44.51 with a cv of 77% in item F the mean litter was 47 g/m^2 ±7.21 with a cv of 46%. In summer season, the item A mean litter was 35g/m^2+13.01 with a cv of 1.11%, the item B mean litter was 205g/m^2 ±29.96 with a cv of 44%, in item c mean litter was 420g/m^2 ±81.24 with a cv of 58%, in item D mean litter was 124 g/m^2 ±66.43 with a cv of 1.61%, in item E mean litter was 223g/m^2 ±44.67 with a cv of 60%. In pre monsoon season, the item A mean litter was 41g/m^2 ±14.64 with a cv of 1.07, the item B mean litter was 223g/m^2 ±45.96 with a cv of 62%, in item C mean litter was 150 g/m^2±56.52 with a cv of 1.13% in item D mean litter was 5g/m^2 ±2.78 with a cv of 1.67%, in item F mean litter was 95 g/m^2 ±28.40 with a cv of 90%. In monsoon season the item A mean litter was 20g/m^2 ±11.11 with a cv of 1.67%, the item B mean litter was 260g/m^2 ± 58.60 with a cv of 68%, the item c mean litter was 80g/m^2±22.74 with a cv of 85%, the item D mean litter was 100g/m^2 ± 55.56 with a cv of 1.67%, the item F mean litter was 110g/m^2 ±26.06 with a cv of 71%. In post monsoon season, the minimum beach litter in marina is 25g/m^2± 622.55 (variance±S.E), Jan' 14, maximum is 2125g/m^2±622.55, Feb'14, mean is 1216.67g/m^2± 622.55, cv is 51%, in Besant nagar beach, the mean litter is 434.33 g/m^2±227.47, the minimum litter is 0g/m^2± 227.47, Jan'14, the maximum litter is 785 g/

Table 1. Two Way Anova Table

SN.	Source of Variation	SS	df	Ms	F	P	F crit	s/ns
1	beach	462588.6	2	231294.3	14.41	1.56E-06	3.04	s(p≤0.05)
2	month	658254.1	11	59841.28	3.72	8.27E-05	1.84	s(p≤0.05)
3	beach X month	563673.4	22	25621.52	1.59	0.051	1.60	s(p≤0.05)
	within	2888481.0	180	16047.12				
	Total	4572997.0	215					

m^2±227.47, Mar'14, cv is 50%, in thiruvanmiyur mean is 190.67g/m^2 ± 93.27, minimum is 27g/m^2± 93.27, Jan'14, maximum is 350 g/m^2± 93.27, Feb' 14, cv is 46%. In summer season, the mean beach litter in marina is 1211.667g/m^2 ± 307.90, minimum is 760g/m^2 ± 307.90, May'14, maximum is 1800g/m^2±307.91, June'14, cv is 30%, in Besant nagar beach, the mean beach litter is 280.33g/m^2±96.18, the minimum litter is 131 g/m^2 ± 96.18, Apr'14, the maximum litter is 460 g/m^2± 96.177, May'14, cv is 36%, in Thiruvanmiyur beach, mean beach litter is 186.67g/m^2± 36.55, minimum is 130g/m^2± 36.66, May'14, maximum is 255g/m^2 ±36.55, Apr' 14, cv is 25%. In pre monsoon season, the mean beach litter in Marina is 550g/m^2 ± 332.92, minimum beach litter is 0.0g/m^2 ± 332.92, Aug'14, maxi mum is 1150g/m^2 ± 332.92, Jul'14, cv is 50%, in Besant nagar litter is 233.333g/m^2 ± 185.89, minimum is 0.00g/m^2± 185.59, Aug' 14, maximum is 600g/m^2±185.59, Jul'14, cv is 55%, in Thiruvanmiyur, mean litter is 73.33 g/m^2 ± 63.60, Aug'14,maximum is 200g/m^2±63.60, Jul'14, cv is 55%. In monsoon season, the mean beach litter in Marina is 366.67g/m^2 ± 216.67, minimum is 0.00g/m^2± 216.67, O'14, maxi mum is 750g/m^2 ± 216.67, cv is 50.0%, in Besant nagar mean litter is 100 g/m^2 ± 100, minimum is 0.00 g/m^2 ±100, maximum is 300 g/m^2 ± 100, Nov'14, cv is 58%, in Thiruvanmiyur beach mean litter is 483.33g/m^2±305.96,O'14, maximum is 1050g/m^2 ± 305.96, Nov'14, cv is 51%. The total mean beach litter in Marina is 836.25 g/m^2 ± 206.07, minimum is 0.00g/m^2 ± 206.07, Aug & Oct'14, maximum is 2125g/m^2±206.07, F'14,cv is 85%, in Besant nagar beach, the mean total beach litter is 262g/m^2 ± 78.04, minimum is 0.00g/m^2 ± 78.04, Aug, Oct & Dec'14, maximum is 785g/m^2 ± 78.04, Mar'14, cv is 1.03%, in Thiruvanmiyur beach, the mean litter is 233.50 g/m^2± 83.60, the minimum is 0.00g/m^2± 83.60, Aug and Oct'14 and maximum is 1050 g/m^2 ± 83.60, Nov '14, cv is 1.24%. The coefficient of variation was lowest in Marina beach in June'16 and highest in Jan"14. In Besant nagar beach, the cv is lowest in Feb"14 and highest in Jan"14. In Thiruvanmiyur beach, the cv is lowest in Feb"14 and highest in Jan"14. In Marina beach the cv is, Aug"14<Oct"14 <Jun"14< Feb"14< Jul"14<Apl"14<Mar"14<Sep"14<Nov"14< Dec"14< May"14<Jan"14. In besant nagar beach, the cv is Aug"14<Dec"14<Oct"14<Fe b"14<Mar"14<Apl" 14<Jul"14<May"14<Jun"14<Nov"14<Jan"14< Sep"14. In Thiruvanmiyur beach, the cv is Oct"14<Aug"14<Feb"14<Apl"14<Mar"14<Nov"14< Dec"14<Jul"14<Jun"14<May"14<Sep"14<Jan"14. The classification of beach litter, 2014 for Marina beach at 1 factor analysis is significant at 5% level of significance. Grand mean is 1640.58±157.49, cd value at 5% level of significance is 404.88, at 1% level of significance is 635.04,cv is 9.60%. Mean comparision for LSD was also made and among the classifications of A, B, C, D, E & F, the classification C3 is most significant and least significant difference is in the beach litter classification of C1,C4 and C6. The classification of

beach litter, 2014, for Besant nagar is significant at 5% level of significance. Grand mean is 584.67 ± 125.82. cd at 5% level of significance is 323.46 ± 125.82, cd at 1% level of significance is 507.34 ± 125.82, cv is 21.52%. The classification of beach litter, 2014 for Thiruvanmiyur is significant at 5% level of significance, grand mean is 517.42, sed is 71.94, cd(0.05) is 184.95, cd(0.01) is 290.09,cv is 13.90%, mean comparision by LSD is c3 is the best significant and least significant is c2, c4 and c6. In 2 factor analysis, the grand mean is 1069.19. The factors classification and location are significant and the interaction factors of classification and location are non significant, cv is 67.56%. in LSD, group,c3 has the best significant and the group,c1,c4 and c5 has the least significant. Among the locations in LSD, marina and Thiruvanmiyur has the best significance and the locations, Besant nagar and Thiruvanmiyur has the least significant. In 3 factor analysis, the individual factors of 12 months, classification, c1, c2, c3, c4, c5 and c6 the three different locations, Marina, besant nagar and Thiruvanmiyur are significantly different from each other. The interactions effect of classifications and locations, month and locations, month, classifications and locations are non significant both at 5% and 1% level of significance, cv is 13.36%. In LSD representation, among the months, the months of Feb, Mar, Apr, May, June, and July are significantly different and the months Jan, Aug, Sep, Oct, Nov and Dec are non significant. Among the classifications, c3, chappals is the best significant at 5% level and the least significant is c5, Electronics and electrical items in the beach. Among the locations, Marina beach has most significance than the other 2 beaches selected.

Hydrography

At the time of sampling for beach litter the hydrography data is as follows, in Jan'14 to June'14, in Marina, mean temperature is 29.98°C ± 0.70, minimum

temperature is 27.30 °C ± 0.70, J'14, maximum temperature is 32 °C ± 0.70, Apr'14, cv is 6%, mean salinity is 34.17 ppt ± 0.40, minimum salinity is 33ppt ± 0.40, May'14, maximum salinity is 35 ppt ± 0.40, Apr' 14, cv is 3%, mean pH is 8.11± 0.03, minimum pH is 8.01 ± 0.03, F'14, maximum pH is 8.17±0.03, Apr' 14, cv is 1%, mean do is 3.36ml/l±0.12, minimum is 3.11 ml/l ± 0.12, June'14, maximum is 3.87 ml/l ± 0.12, Jan'14, cv is 9%. In July'14 to Dec'14 in Marina, mean temperature is 29.02 °C ± 0.78, minimum temperature is 26°c± 0.78,D'14, maximum temperature is 31.0 °C ± 0.78, S'14, cv is 7%, mean salinity is 33.17ppt ± 0.79, minimum salinity is 30ppt±0.79,O'14, maximum salinity is 35ppt ±0.79, July and Aug'14, cv is 6%, mean pH is 8.23±0.03, minimum pH is 8.14 ± 0.03, S'14, maximum pH is 8.30± 0.03, O & D'14, cv is 1%, mean do is 3.13 ml/l±0.15, minimum is 2.54 ml/l±0.15, D'14, maximum is 3.52ml/l±0.152, S'14, cv is 11.9%. In Jan'14 to June'14, in besant nagar the hydrography data is as follows, mean temperature is 30.26°c ±0.83, minimum temperature is 27.00°C ± 0.83, Jan'14, maximum temperature is 32.50°C ± 0.83, Apr'14,cv is 7%, mean salinity is 34.33ppt ± 0.21, minimum Salinity is 34 ppt±0.21, Mar'14, maximum salinity is 35 ppt±0.21, Apr'14, cv is 2%, mean pH is 8.12 ± 0.02, minimum pH is 8.04±0.02, Feb'14, maximum pH is 8.16± 0.012, Apr'14, cv is 6% ,mean do is 3.36 ml/l±0.16, minimum is 2.78 ml/l ± 0.12, June'14, maximum is 3.92 ml/l±0.16, Jan'14, cv is 9%. In July'14 to Dec'14 in Besant nagar, mean temperature is 28.85°C ± 0.69, minimum temperature is 26.10 °C ± 0.69, D'14, maximum temperature is 31.0 °C ± 0.78, O'14, cv is 7%, mean salinity is 33ppt ±1.13, minimum Salinity is 30ppt±1.13,O and N'14, maximum salinity is 36ppt± 1.13, A'14,cv is 8%, mean pH is 8.20 ± 0.06, minimum pH is 8.03±0.06,July & Aug'14, maximum pH is 8.38± 0.057, O'14, cv is 0.02, mean do is 3.17ml/l ±0.13, minimum is 2.54ml/l ±0.13, D' 14, maximum is 3.39ml/l± 0.13, N'14,cv is 10%. In Jan'14 to June'14 in Thiruvanmiyur, the hydrography data is as follows mean temperature is 30.59 °C± 0.61, minimum temperature is 28.00°C± 0.61, Jan' 14, maximum temperature is 32.02°C ± 0.61, Mar'14, cv is 5%, mean salinity is 34.33ppt ± 0.33, minimum Salinity is 33ppt ± 0.33, June'14, maximum salinity is 35ppt±0.33, May'14, cv is 2%, mean pH is 8.14± 0.01,minimum pH is 8.08± 0.01, Feb'14, maximum pH is 8.18 ± 0.01, Mar'14,cv is 1%, mean do is 3.28ml/l±0.18,minimum is 2.63 ml/l±0.18,June' 14, maximum is 3.97ml/l± 0.18, Jan'14, cv is 14%. In July'14 to Dec'14 in Thiru- vanmiyur, mean temperature is 29.52°c ±0.89, minimum temperature is 27°c±0.89,D'14, maximum temperature is 33.0°c± 0.89, S'14, cv is 7%,mean salinity is 33.33ppt ± 1.12, minimum salinity is 30ppt ±1.12, O and N '14, maximum salinity is 36ppt±1.12, July & Aug'14, cv is 8%, mean pH is 8.26± 0.03, minimum pH is 8.21 ± 0.03, July and Aug'14, maximum pH is 8.38± 0.03, O'14,cv is 1%, mean do is 3.19 ml/l ± 0.10, minimum is 2.75ml/l±0.10, D'14, maximum is 3.48 ml/l ± 0.10, N'14, cv is 8%.

Conclusion

The percentage increase of item B from A in marine beach is 57.43%, item C from item B is 36.88%, item C is 71.88%, higher than item D. Among the three beaches tested, total weight is more in item C in Marina beach followed by Besant nagar beach and then by Thiruvanmiyur beach. Percentage increase of total weight of litter is 65.89% in Besant nagar beach in item B from that of item A, item C is 19.53% decrease from that of item B, item D is 69.34% decrease than that of item c. Percentage increase of total weight of litter in Thiruvanmiyur region is 63.21% of item B from that of item A, % decrease of item C is 37.57% from that of item B, % increase of item D is 0.89% from item C. Average total weight of Thiruvanmiyur beach is 40.31% per meter square area, from that of Marina beach, 81.30% from that of Besant nagar beach. (Kungtac Ra., *et al.* 2013) The cumulative variance is highest in pre-monsoon season, 86.80% followed by post monsoon season, 78.193%, summer season, 76.53% and monsoon season, 62.80%.The highest eigen value is in post monsoon season, 3.58 followed by summer season, 2.68, pre monsoon season, 2.18 and monsoon season, 1.96. Gradually the individual percentage variance decreases from the post monsoon season, 59.74% to monsoon season, 32.63% in the first component tested.

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References

Balance, A., Ryan, P.G. and Turpie, J.K. 2000. How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. *South African Journal of Science.* 96 (5) : 210-213.

Carpenter, E.J. and Smith, K.L. 1972. Plastics on the Sargasso sea surface, Science, 175,1240 -1241.

Carpenter, E.J., Anderson, S.J., Harvey, G.R., Miklas, H.P., Peck, B.B. 1972. Polystyrene sphereles in coastal waters. *Science.* 178 : 749-750.

Caulton, E. and Mocogni, M. 1987. Preliminary studies of man made litter in the Firth of Forth. Scotland. *Marine Pollution Bulletin.* 18(8):446-50.

Clark, B.B. 1997. *Marine Pollution.* Clarendon Press. Oxford.

Gregory, M.R. 1996. Plastic"scrubbers" in hand cleansers. a further (and minor) source. for marine pollution identified. *Marine Pollution Bulletin*. 32 : 867-871.

Jayasiri, H.B., Vennila, A. and Purushothaman, C.S. 2014. Spatial and temporal variability of metals in inter tidal beach sediment of Mumbai, India. *Environment Monitoring and Assesment.* 186 : 1101-1111.

Kungtac Ra, Eun-Soo Kim, Kyung Tae Kim, Joung Keun Kim Jung Moo Lee Jin You ng Choi, 2013 Assessment of heavy metal contamination and its ecological risk in the surface sediments along the coast of Korea. *Journal of Coastal Research.* Special Issue. No. 65 : 105-110.

Laist, D.W. 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Marine Pollution Bulletin.* 18: 319-326.

Laist, D.W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In Coe,

Rogers, J.M. and D.B.(Eds.) *Marine debris – Sources, Impacts and solutions.* Springer Verlag, New York, pp.99-139.

Minchin, D. 1996. The pellets and plastics as attachment surfaces for lapadid cirripedes in the North Atlantic ocean. *Marine Pollution Bulletin.* 32: 855-859.

Quayle, D.V. 1992. Plastics in the marine environment: Problems and solutions. *Chemical Ecology.* 6: 69-78.

Ryan, P.G., Swane Poel, D. 1996. Cleaning beaches. sweeping the rubbish under the carpet. *South African Journal of Science.* 1996 (92) : 275-276.

Santos, I.R., Friedrich, A.C. and Duarte, E. 2003. Percepcoes sobre o lixo na praia do Cassino, RS., Brasil, Mundo & Vida,2003,4(1):11-7

Silva. Iniguez, L. and Fischer, DW. 2003. Quantification and classification of marine litter on the municipal beach of Ensenada, Baja California, Mexico, *Marine Pollution Bulletin.* 2003 : 46 (1), 132-8.

Zitko, V. 1993. Expanded polystyrene as a source of contaminants. *Marine Pollution Bulletin.* 26: 584-585.