COASTAL POLLUTION IN ISTANBUL

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Abstract: Quantities of pouches filled with marine debris and packaging (kg) collected during coast and beach cleaning, the amount of waste (m^3) collected during sea surface cleaning and moss work (kg), and the amount of sludge removed during stream rehabilitation (m^3) were analyzed in Istanbul, Turkey between 2013 and 2016. Seasonal changes have been identified in these quantities. The quantity of packaging pouches collected during coastal cleaning had increased over time, reached its highest level in 2016. High values were observed in September due to heavy rainfall and in the summer due to waste transported from picnic areas. However, low values were seen for all parameters in winter. This increase in waste quantities can be eliminated by taking various precautions such as recycling or reusing plastic bags and bottles instead of throwing waste away. For a cleaner sea and coast, public education can be developed to encourage these precautions. In addition, economic measures can be taken such as selling plastic shopping bags instead of giving them free of charge.

Keywords: Coast, Beach, Pollution

İstanbul'da Kıyı Kirliliği

Öz: İstanbul'da 2013 ve 2016 yılları arasında kıyı ve plaj temizliğinde toplanan deniz ve ambalaj atıklarının poşet sayısı, deniz yüzeyi temizliği ile toplanan atık miktarı (m³), yosun çalışması ile toplanan atık miktarı (kg) ve dere ıslahı ile çıkarılan çamur miktarı (m³) verileri analiz edilmiştir. Bu miktarlarda mevsimsel değişiklikler tespit edilmiştir. Kıyı temizliği sırasında toplanan ambalaj poşetlerinin miktarının zamanla aşırı yükseldiği ve 2016'da en yüksek seviyesine ulaştığı görülmüştür. Piknik alanlarından taşınan atıklardan dolayı yaz aylarında ve yoğun yağışla sürüklenmeden dolayı eylül ayında yüksek değerler gözlenmiştir. Ancak kış mevsiminde tüm parametreler için düşük değerler görüldü. Atık miktarlarındaki bu artış, atıkların atılması yerine plastik torbaların ve şişelerin geri dönüştürülmesi veya yeniden kullanılması gibi çeşitli önlemler alınarak giderilebilir. Daha temiz bir deniz ve sahil için, bu önlemleri teşvik etmek amacıyla kamu eğitimi geliştirilebilir. Ayrıca, plastik poşetler alışverişlerde ücretsiz verilmek yerine satılması gibi ekonomik tedbirler alınabilir.

Anahtar Kelimeler: Kıyı, Kumsal, Kirlilik

1. INTRODUCTION

Marine debris is mostly plastic (Pasquini et al., 2016). Plastic packaging pollution results from the accumulation of waste from marine transportation (Scott, 1972). Tourism, fishing, shipping and passenger vessels increase marine debris (Polasek et al., 2017). According to a study of Catalan shores by Ariza et al. (2008), urban beaches had a higher density of waste storage compared to urbanized beaches during the swimming season (Ariza et al., 2008). Plastic bag waste, when seen at high levels in municipal waste water, causes environmental problems such as resource depletion, blocked waterways, harm to animals and damage to soil, landscapes

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and trees (Bahri, 2005). Plastic waste increases with the growth of the economy, human activity and industrial processes. It is difficult to transport plastic waste because of the deteriorated properties of the plastic. In addition, the harmful effects of plastics and associated toxic hazards are a real threat to human health and the environment. Sea birds and turtles can eat floating waste. As a result they can choke or inhibit their digestive system (Ocean Conservancy, 2016). Decompositions of coastal plastic wastes are disturbed at much higher thermal values than new plastics (Khariri, 2012). The decomposition of plastics on the beaches results in persistent organic pollutants carried to the water by wind and currents (Andrady, 2011). Solid waste production increases along with population and local food preparation habits often produce food waste. Focusing on waste disposal instead of waste prevention causes excessive use of plastic bags and containers (Maziku, 2014). If plastic packaging is not properly collected, it can reduce ocean productivity (Lachmann, 2016). Golik and Gertner found that the contents of beach garbage were mostly related to recreational activities, containing such items as beverage bottles, food containers, cosmetics, plastic bags, clothes, foam, rubber and cushions. The bag of beach garbage contained 71.6% plastic material, 7.9% wood, 5.7% metal, 3.1% glass and 11.7% other materials (Golik and Yaron, 1989). Plastic does not sink and moves to any place in the world with currents (Isangedighi et al., 2018).

One way to reduce plastic waste is awarding fishermen for bringing their fishing gear on board when returning rather than throwing it into the sea. Because most sea waste comes from the land and contains plastic, economic instruments can help reduce marine litter (Oosterhuis et al., 2014). Marine debris can also be cleaned by government agencies and through campaigns that promote public participation. Bottles and plastic bags can be reused or recycled if they can be prevented from being thrown around the sea (Liu et al., 2013). The major ocean plastic accumulation zone can be characterised and quantified by The Great Pacific Garbage Patch model (Lebreton et al., 2018). Clean and efficient transportation can be made by Green Port concept protecting marine aquatic life and ecosystem (Satir and Dogan-Saglamtimur, 2018). In this study, collected wastes (marine debris, packaging, sea surface waste, moss and sludge) from the Istanbul coast between 2013 and 2016 were statistically analysed. Association between the collected wastes and population was determined by Pearson correlation. Then coast waste management and shore protection measures were recommended.

2. STUDY AREA

Our study area is the Marmara Sea near Istanbul, Turkey. The Marmara Sea is a recreational area for people in Istanbul, which is the most crowded second city in Europe (Figure 1).

Figure 1:
Sea of Marmara in Istanbul, Turkey (Worldatlas, 2017).

2. MATERIALS AND METHODS

Beach and coast cleaning squads clean floating waste and waste on the shore, covering 600 km of coastlines, piers, rocky shores, beaches and sea surfaces during the year. 31 teams include 186 staff were working in different locations (Avcılar, Silivri, Yenikapı, Catalca, Halic, Karakoy, Sariyer, Uskudar, Beykoz, Agva, Kadikoy, Tuzla, Sile, and Eyup) across the Istanbul. In addition, they also clean the sand on the beach during the swimming season (Figure 2a, b). For beach cleaning, they had hand harrow, shovel, and handle hook. With eight specially designed surface cleaning boats, waste floating on the Marmara Sea and the Bosporus and Halic waterways are cleaned year-round (Figure 2c). When sea and weather conditions are favourable, two divers also carry out underwater cleaning of densely used piers and bays (Figure 2d). Dredging services also take place in the estuaries and river mouths of the Golden Horn and at the mouths of 15 other rivers to prevent floods and bad smells (Figure 2e). To control marine pollution from ships within the Istanbul's sea boundaries, inspections are carried out by boat and helicopter, and sanctions are imposed if a violation is detected (Ministry of Environment and Urbanism for the Delegation of Authority, 2011) (Figure 2f). Licensed waste collection vessels collect petroleum-derived wastes specified in the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex I, such as Bilge water, sludge and dirty ballast, harmful liquids specified in Annex II, contaminated waters specified in Annex IV, and waste specified in Annex V (The International Convention for the Prevention of Pollution from Ships, 1973) (Figure 2g). The Haydarpasa Waste Reception Facility accepts oil and petroleum wastes defined by MARPOL Annex 1 collected from vessels for recycling and disposal after dehydration (Figure 2h). The new Galata and Ataturk bridges are opened for the transit of ships twice a week in the winter months and once a week in the summer months so they are undergoing maintenance and repair work (Figure 2i) (IBB, 2017).
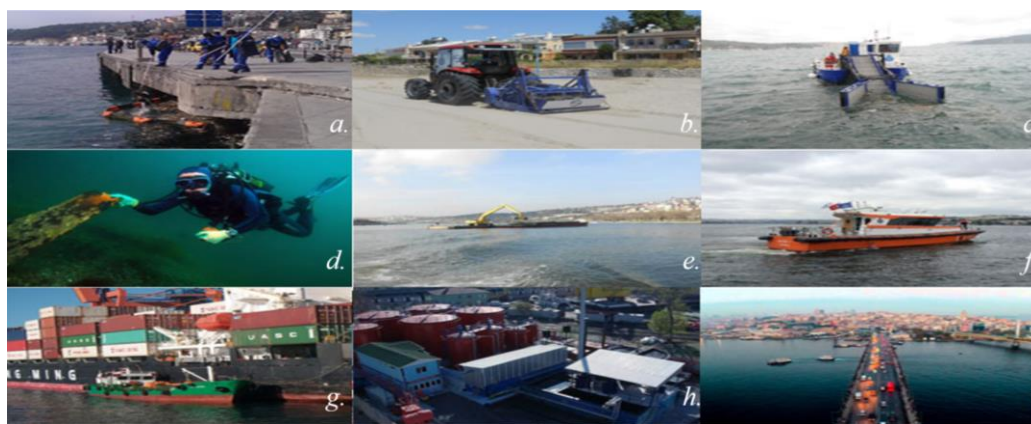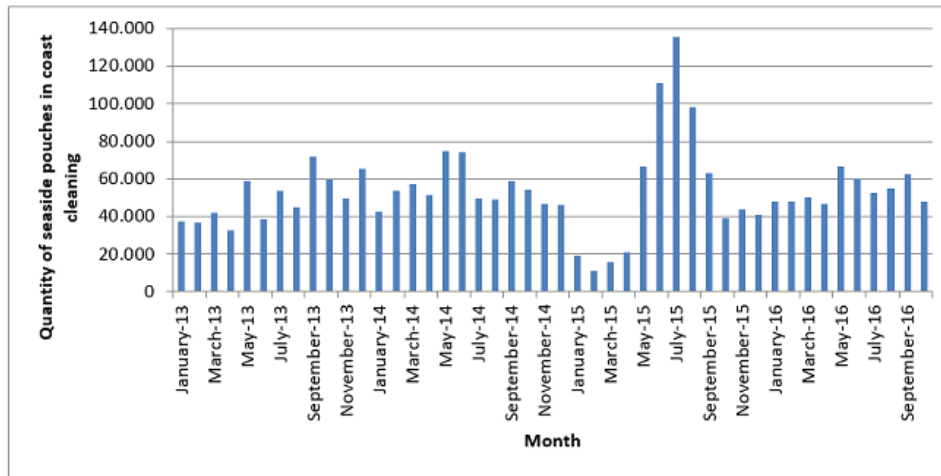

Figure 2:
a. Coast cleaning b. Beach cleaner c. Sea surface cleaning d. Underwater cleaning e. Bottom mud dredging f. Prevention of ship-borne marine pollution g. Waste collection from ships h. Waste reception facility i. Ataturk (Unkapani) bridge 12(Smith,1991b)

Collected wastes were statistically researched and Pearson correlation in Excel was used to determine the relation with population and migrants.
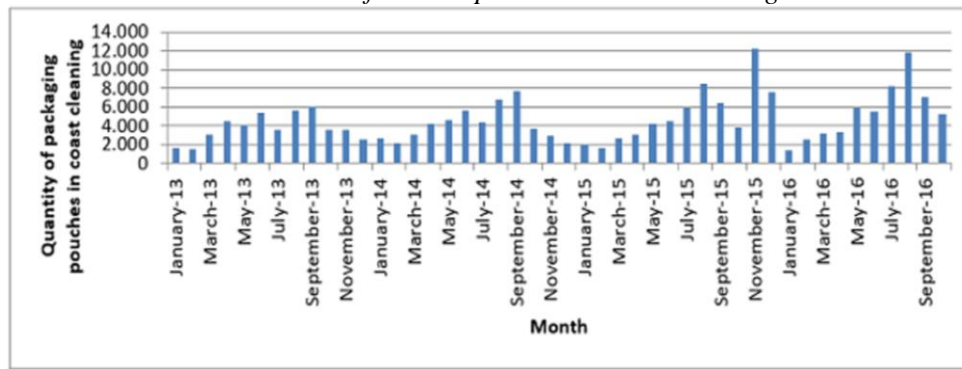
3. RESULTS

We analyzed the number of seaside pouches and packaging pouches collected during coast and beach cleaning between 2013 and 2016 (Figures 3, 4, 5 and 6). The maximum values of seaside pouches in coast and beach cleaning and the maximum value of packaging pouches in
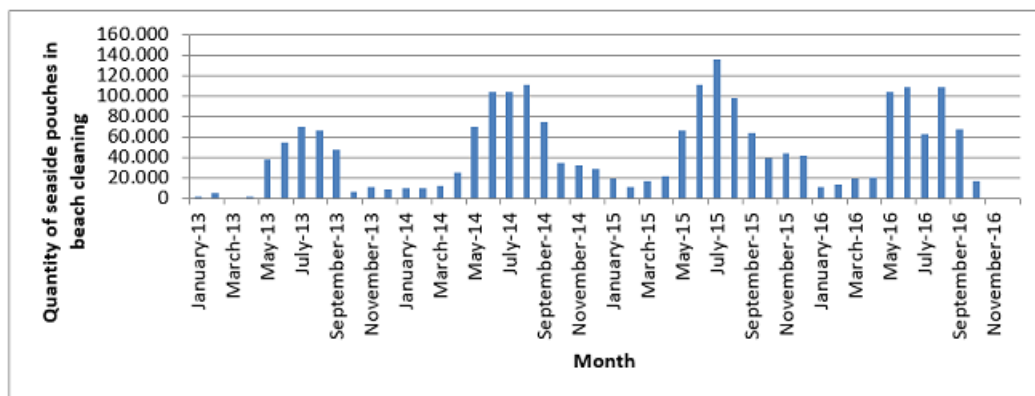
coast cleaning were in 2015. The minimum values of seaside pouches in beach cleaning were in 2013. The minimum of packaging pouches in coast and beach cleaning was in 2016.

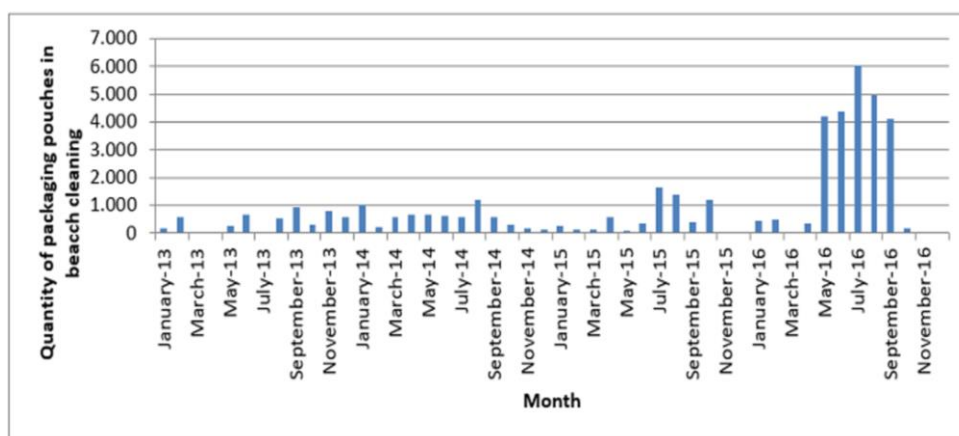*Figure 3:*
The number of seaside pouches in coast cleaning

Figure 4:
*The number of packaging pouches in coast cleaning*

Figure 5:
*The number of seaside pouches in beach cleaning*

We analyzed quantities of seaside pouches and packaging pouches (kg) collected in coastal cleaning between 2013 and 2016 in Istanbul (Figures 7 and 8). The maximum values of seaside pouches and packaging pouches (kg) in coastal cleaning were in 2015, whereas the minimum values were in 2013.
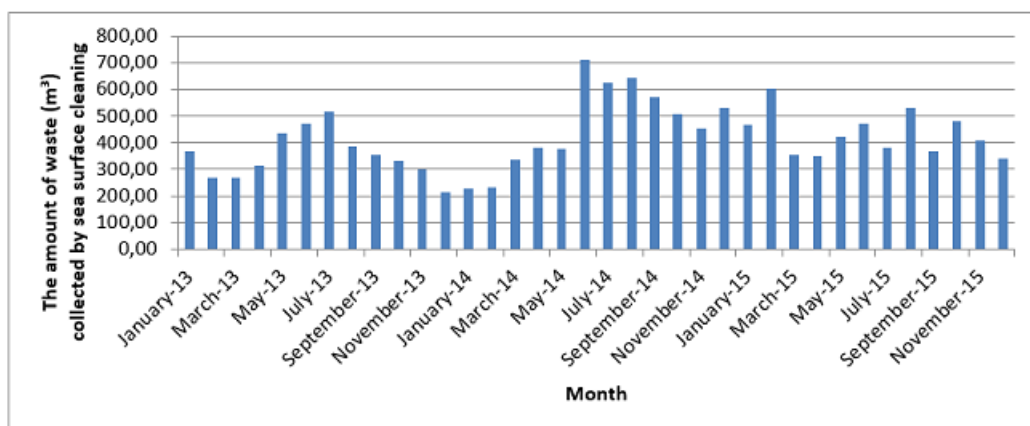
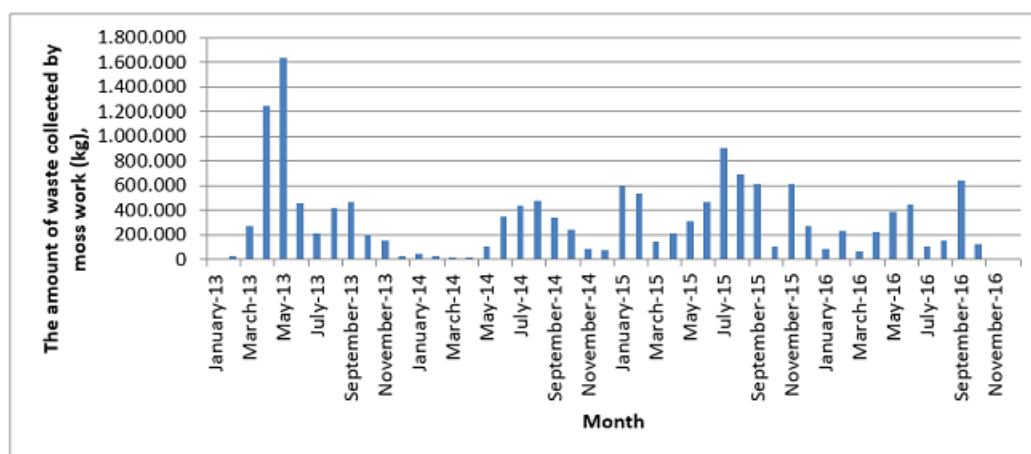***Figure 6:***
The number of packaging pouches in beach cleaning
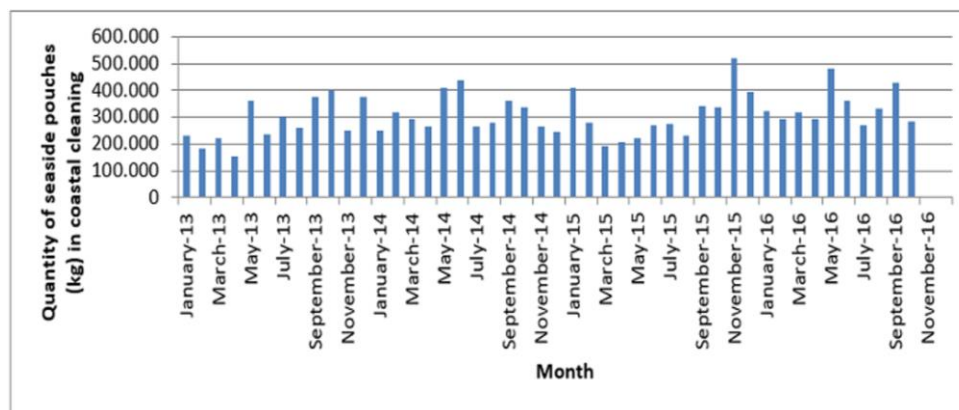
Figure 7:
Quantities of seaside pouches (kg) in coastal cleaning
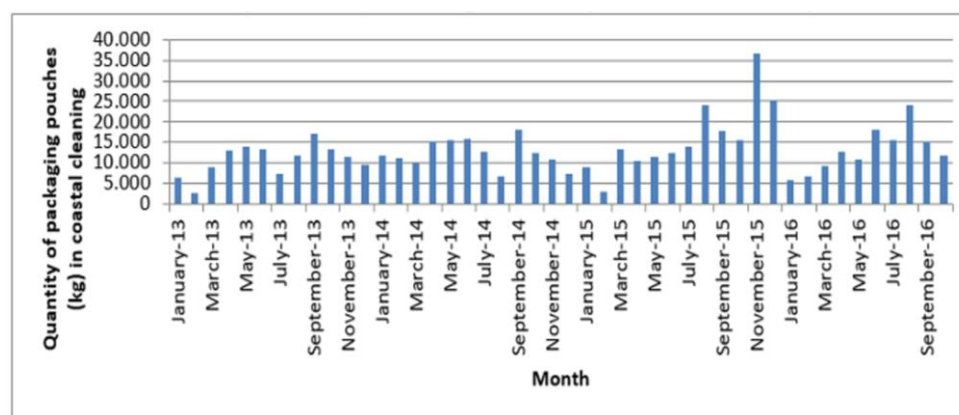
Figure 8:
Quantities of packaging pouches (kg) in coastal cleaning

Figure 9:
The amount of waste (m³) collected by sea surface cleaning

Figure 10:
The amount of waste collected by moss work (kg)

We also analyzed the amount of waste (m³) collected during sea surface cleaning, the amount of waste collected by moss work (kg), and the amount of sludge removed during stream rehabilitation (m³) (Figures 9, 10 and 11). The maximum and minimum values of waste (m³) collected during sea surface cleaning were in 2014 and 2013, respectively. The maximum and minimum values of waste collected by moss work (kg) were in 2013 and 2014, respectively. The maximum and minimum values of sludge removed during stream rehabilitation (m³) were in 2013 and 2015, respectively (Table 1).

The values representing the Pearson correlation between Istanbul's total population and average values of parameters were 0.67 (quantity of seaside pouches in coast cleaning), 0.99 (quantity of packaging pouches in coast cleaning), 0.83 (quantity of seaside pouches in beach cleaning), 0.7 (quantity of packaging pouches kg in coast cleaning), 0.88 (quantity of seaside pouches in coastal cleaning) and 0.75 (quantity of packaging pouches in beach cleaning). The Pearson correlation coefficient between Istanbul's population and the minimum value of amount of waste collected during sea surface cleaning was 0.93, and Pearson correlation coefficient between Istanbul's population and the minimum value of waste amount collected during moss work was 0.82. Therefore, we determined the strength of the positive linear association between variables using Pearson correlation. Correlation values showed that pollution increased along with population between 2013 and 2016.

Table 1. Statistical analysis of parameters

	Year	Max	Min	Average	Std.Dev.
Quantity of seaside pouches in coast cleaning	2013	72023	32981	49357	12625
	2014	74955	42675	54962	10316
	2015	135663	11218	55527	40596
	2016	66664	46732	53764	7071
Quantity of packaging pouches in coast cleaning	2013	5997	1467	3756	1455
	2014	7750	2110	4178	1806
	2015	12276	1702	5238	3096
	2016	11896	1350	5437	3097
Quantity of seaside pouches in beach cleaning	2013	69295	515	27807	27263
	2014	110509	9043	50942	39149
	2015	135663	11218	55527	40596
	2016	108873	10766	53004	42192
Quantity of packaging pouches (kg) in coast cleaning	2013	17067	2734	10729	3905
	2014	17992	6809	12258	3419
	2015	36624	2775	16035	8966
	2016	24012	5843	13001	5506
Quantity of seaside pouches (kg) in coastal cleaning	2013	400060	155160	279438	81560
	2014	435865	243620	309536	64159
	2015	518877	193370	305710	97573
	2016	483175	268684	338494	68222
Quantity of packaging pouches in beach cleaning	2013	945	37	442	304
	2014	1185	117	559	325
	2015	1641	89	616	576
	2016	6035	17	2505	2407
The amount of waste (m³) collected by sea surface cleaning	2013	518	215	352	89
	2014	713	227	466	160
	2015	602	339	431	81
The amount of waste collected by moss work (kg)	2013	1639390	29000	466223	513967
	2014	475060	12800	184003	172656
	2015	905470	108550	454808	245767
	2014	8400	2525	5505	1994
	2015	7603	472	3467	2339

There was a negative association between pollution parameters and 10–14-year-olds who migrated to Istanbul. There was also a negative association between pollution parameters and 25–34-year-olds who migrated to Istanbul. On the other hand, there was positive association between pollution parameters and 0–9, 15–24, 35–44 and 50–90-year-olds who migrated to Istanbul.
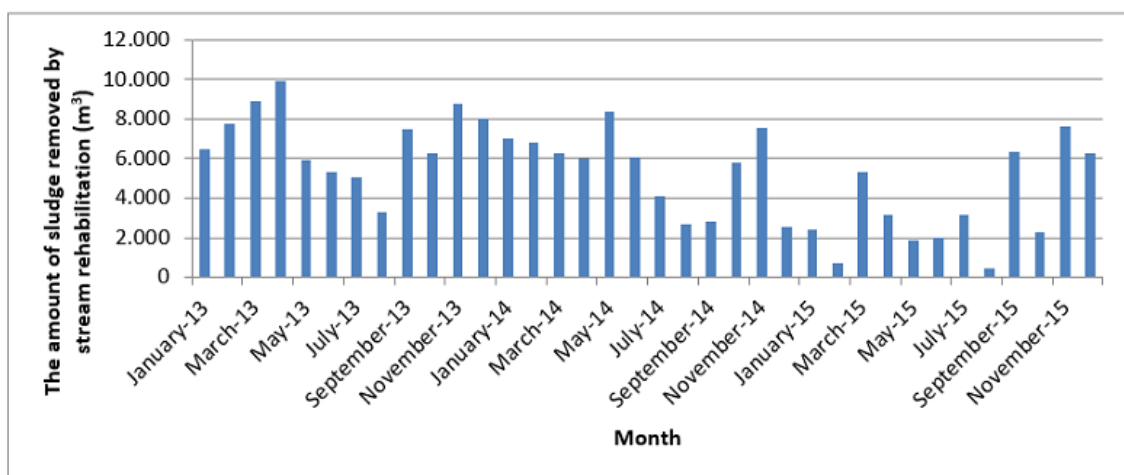
Figure 11:
The amount of sludge removed by stream rehabilitation (m³)

4. CONCLUSIONS

The amounts for all parameters were high during the summer months and in September, but lower in winter. Also, the quantity of packaging pouches collected during coast cleaning in 2016 was much higher than in previous years.

The maximum values of waste (m³) collected during sea surface cleaning and moss work (kg) were in 2014 and 2013, respectively, and the maximum value of sludge removed during stream rehabilitation (m³) was in 2013. The Pearson correlation values showed a strong positive association between Istanbul's population and the average values of seaside pouches and packaging pouches collected during coast cleaning, seaside pouches collected during beach cleaning, packaging pouches collected during coast cleaning, seaside pouches collected during coastal cleaning, and packaging pouches collected during coastal cleaning. The Pearson correlation coefficient between Istanbul's population and the minimum values of waste collected by sea surface cleaning or moss work was also high. Therefore, pollution increased along with population between 2013 and 2016. There was a negative association between pollution parameters and people aged 10–14 and 25–34 who migrated to Istanbul; however, we found a positive association between pollution parameters and people aged 0–9, 15–24, 35–44 and 50–90 who migrated to Istanbul.

The amount of land-based marine litter from 192 countries (China, Indonesia, the Philippines, Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, Bangladesh, South Africa, India, Algeria, Turkey, Pakistan, Brazil, Burma, Morocco, North Korea and the United States etc.) in 2010 was 4.8–12.7 million metric tons and plastic marine debris from Turkey in 2010 was between 0.07 and 0.19 million metric tons (Jambeck et al., 2015). Therefore the marine debris from Istanbul coast between 2013 and 2016 was extremely lower than the marine debris from other countries and Turkey in 2010. 300 bags of debris comes from ships dumping offshore were collected in 2017 on beaches in Istanbul's Kilyos (Daily Sabah with Dogan News Agency, 2017) A survey of the Dutch coast from 2000 to 2006 found 500 tons of debris on sea floor (Elias, 2018). Kuwait Dive Team had collected more than 2700 tons of marine debris in the last decade from Mediterranean Sea, Red Sea, and Arabian Gulf (Ocean Conservancy, 2017). And these amounts are high with compare to Istanbul coast's yearly values.

The findings of this work can help support efforts to improve the coasts of Istanbul and its beaches and waste management, and may benefit those responsible for waste production and management characteristics. Coast waste management can reduce waste from coast through material reuse, recycling and composting. Campaigns of waste abatement and awareness-raising

such as 'Love Food, Hate Waste' programs, 'Get it Sorted' campaign (Willis et al., 2018) can be built to reduce waste. It has been recommended that future work should be compositon, origin, and abundance of marine debris along Istanbul coast. The adverse environmental impacts of plastic bag waste, its main causes, and short- and long-term remedial policies and technical packages should be identified. Changes in consumer behaviour, such as the rational use and reuse of plastic bags, should be encouraged. To this end, people can be educated through public awareness campaigns about the production, use and disposal of plastic bags, and the surrounding effects of plastic waste. Compostable bags that perform well should also be developed, and reusable bags can be sold at easily accessible places. Additionally, plastic shopping bags are currently free, but a fee could be added to promote more responsible use.

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REFERENCES

1. Ariza, E., Jiménez, J.A., and Sardá, R. (2008) Seasonal evolution of beach waste and litter during the bathing season on the Catalan coast, *Waste Management*, 28(12), 2604-2613. *doi:* 10.1016/j.wasman.2007.11.012

2. Bahri, G. (2005). Sustainable Management of Plastic Bag Waste. The Case of Nairobi, Kenya, *MSc. Thesis*, Science in Environmental Management and Policy Lund, Sweden.

3. Daily Sabah with Dogan News Agency, (2017) Illegally dumped debris washes ashore on beaches in Istanbul's Kilyos. Access address: https://www.dailysabah.com/istanbul/2017/03/06/illegally-dumped-debris-washes-ashore-on-beaches-in-istanbuls-kilyos (Date of Access: 09.11.2018)

4. Elias, S. A. (2018) *Encyclopedia of the Anthropocene*, Elsevier Inc, Oxford.

5. Golik, A., and Gertner, Y. (1989) Solid waste on the Israeli coast composition, source and management, *Proceedings of the second international conference on marine debris*, Hawai, 369-378.

6. IBB, (2017). Access address: http://www.ibb.gov.tr/en-US/Organization/birimler/denizhizmetlerimd/Pages/AnaSayfa.aspx#.WHzKEvCLTct (Date of Access: 01/12/2017)

7. Isangedighi, I. A., David, G. S., and Obot, O. I. (2018) Plastic Waste in the Aquatic Environment: Impacts and Management, *Environment*, 2, 1-31.

8. Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., and Law, K. L. (2015). Plastic waste inputs from land into the ocean, *Science*, 347(6223), 768-771.

9. Khairi, H.M. (2012). Study on Bonding and Chemical Properties of Coastal Plastics Waste, *PhD Thesis*, Malaysia Pahang University Faculty of Chemical Engineering & Natural Resources, Malaysia.

10. Lachmann, F. A. (2016) Marine plastic debris–flows, mitigation measures and environmental evaluation, *Master Thesis*, University of Gothenburg Department of Biological and Environmental Sciences, Gothenburg, Sweden.

11. Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo, S., Schwarz, A., Levivier, A., Noble, K., Debeljak, P., Maral, H., Schoeneich-

Argent, r., Brambini, R. And Reisser, J. (2018). Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific Reports*, 8(1), 4666.

12. Liu, T.K., Wang, M.W. and Chen, P. (2013) Influence of waste management policy on the characteristics of beach litter in Kaohsiung, Taiwan, *Marine Pollution Bulletin*, 72(1), 99-106. *doi:* 10.1016/j.marpolbul.2013.04.015

13. Maziku, J. (2014). Improving Solid Waste Management in the Dar Es Salaam Coastal Belt, Tanzania, *Bachelor Thesis*, Novia University Natural Resources Department Integrated Coastal Zone Management Programme, Tanzania.

14. Ministry of Environment and Urbanism for the Delegation of Authority, (2011). Circular Letter No. 2011/9.

15. Ocean Conservancy, (2016) International coastal cleanup: 2015 Report. Access address: http://www. oceanconservancy.org/our-work/marine-debris/2015-data-release/2015-datarelease-pdf (Date of Access: 01.12.2017)

16. Ocean Conservancy, (2017) International coastal cleanup: 2017 Report. Access address: https://oceanconservancy.org/wp-content/uploads/2017/06/International-Coastal-Cleanup_2017-Report.pdf (Date of Access: 09.11.2018)

17. Oosterhuis, F., Papyrakis, E. and Boteler, B. (2014) Economic instruments and marine litter control, *Ocean & coastal management*, 102, 47-54. *doi:* 10.1016/j.ocecoaman.2014.08.005

18. Pasquini, G., Ronchi, F., Strafella, P., Scarcella, G., & Fortibuoni, T. (2016) Seabed litter composition, distribution and sources in the Northern and Central Adriatic Sea (Mediterranean), *Waste Management*, 58, 41-51. *doi:* 10.1016/j.wasman.2016.08.038

19. Polasek, L., Bering, J., Kim, H., Neitlich, P., Pister, B., Terwilliger, M., Nicolato, K., Turner, C., and Jones, T. (2017). Marine debris in five national parks in Alaska, *Marine pollution bulletin*, *117*(1-2), 371-379. *doi:* 10.1016/j.marpolbul.2017.01.085

20. Satir, T. and Dogan-Saglamtimur, N. (2018) The Protection of Marine Aquatic Life: Green Port (EcoPort) Model inspired by Green Port Concept in Selected Ports from Turkey, Europe and the USA, *Periodicals of Engineering and Natural Sciences*, 6(1), 120-129. *doi:* 10.21533/pen.v6i1.149

21. Scott, G. (1972) Plastics packaging and coastal pollution, *International Journal of Environmental Studies,* 3(1-4), 35-36. *doi:* 10.1080/00207237208709489

22. The International Convention for the Prevention of Pollution from Ships, (1973). Marpol 73/78, clause (i) of Article 7 of the Metropolitan Municipal Law No.5216 and the Regulation on Reception of Wastes from Ships and Waste Control.

23. Willis, K., Maureaud, C., Wilcox, C., and Hardesty, B. D. (2017) How successful are waste abatement campaigns and government policies at reducing plastic waste into the marine environment?, *Marine Policy. doi:* 10.1016/j.marpol.2017.11.037

24. Worldatlas, (2017). Access address: http://www.worldatlas.com/aatlas/infopage/seaofmarmara.htm (Date of Access: 01/12/2017)