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AN INVESTIGATION ON WASTE AMOUNT FROM SHIPS IN ISTANBUL

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ABSTRACT
In Turkey, control studies related to the wastes from ships continue, and the first waste acceptance facility (WAF) from ships was founded in Istanbul: Haydarpaşa WAF. Haydarpaşa WAF has been accepting waste since September 2005 based on the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). The number of transit ships and their disposed wastes have been continuously recorded in a database since September 2005. The main goal of this study is to forecast the amount of different waste collected from transit ships for next two years based on the data recorded between September 2005 and January 2010 using ARMA forecasting model. According to result obtained with the model, the current data remain between the upper and the lower limit values of forecasting data.

KEYWORDS: ARMA, Istanbul, MARPOL, ship, waste, forecasting.

1. INTRODUCTION

The waste disposals form ships pose an important threat to aquatic life It is generally accepted that shipping provides the most cost effective and environmentally sound method of transportation for goods worldwide when compared with road, rail and airfreight. Ships generate various types of waste including glass, metal, and plastic containers, cardboard, packaging materials, oily bilge waters, wastewater, and hazardous waste. Oily and solid waste and hazardous waste from ships have been in the past illegally discharged in the marine environment. Oily and solid waste from ships is simply discharged in ports, but they could be separated before discharging, reused or recycled in ports (Zuin *et al.*, 2009).

The pollution generated by ships including liquid and solid wastes is legislated through the requirements of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) and the International Safety Management (ISM) Code, both of which are under the auspices of the International Maritime Organization (IMO). Legislation is also in place through the European Union (EU) setting requirements for ports to provide reception facilities for ship-generated waste that cannot be disposed of at sea in compliance with the MARPOL 73/78 regulations (Butt, 2007).

MARPOL 73/78 adopted by International Maritime Organization (IMO) established regulations and responsibilities concerning the illegal discharge of oil, chemicals, sewage, and garbage into the sea during normal operations. Governments, for example, are given the responsibility of providing adequate reception facilities for oil and chemical residues, garbage, sewage, ozone-depleting substances, and exhaust cleaning system residues. The provision of adequate reception facilities is an essential requirement for reducing and eventually eliminating pollution from ships (Tanzer *et al.*, 2008).

The Convention includes regulations on the prevention and minimization of pollution from ships occurring through both accidental releases and routine operations. Such convention currently

includes six technical Annexes which are Annex I: Regulations for the Prevention of Pollution by Oil, Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk, Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form, Annex IV: Prevention of Pollution by Sewage from Ships, Annex V: Prevention of Pollution by Garbage from Ships, and Annex VI: Prevention of Air Pollution from Ships (http://www.imo.org). Common waste treatment methods of ship-generated wastes include recycling for oil, oil filters, batteries, aerosols, fluorescent tubes, scrap metals, glasses, electronic equipment, and refrigerators, incineration for oily rags, sludge and medical waste, biological treatment for bilge water, photochemical waste, sewage and grey water, and landfilling for general garbage, food waste, incinerator ash (Butt, 2007). Turkish government also poses a regulation regarding ship-generated waste and cargo residues in port facilities based on a EU directive 2000/59/EC. Ships Waste Collection and Waste Control Regulation was published on December 26, 2004 and revised on March 18, 2010 imposing. Turkey's maritime jurisdiction in the areas of waste produced by ships and cargo residues into the sea in order to protect the marine environment in the prevention and administration, by the responsibility for the establishment and operation of waste reception facilities and waste collection vessels to determine the procedures and principles. This regulation was prepared on the parallel as MARPOL 73/78 International Convention on the Prevention of Pollution from Ships, dated 27/11/2000 and 2000/59/EC on the basis of ships and cargo residues with wastes produced port waste reception facilities used for the European Parliament and Council Directive. This new amendment requires an environmental license for private sectors which receive and treat any waste and cargo residues generated by the ships. In the city of Istanbul, the Metropolitan Municipality has recently received wastes based on the regulation within the scope of MARPOL 73/78; Annex I, Annex IV, and Annex V at Haydarpaşa WAF. Waste acceptances have been made with 12 licensed waste received ships. Data related with the number of ships and volume~~s~~ of wastes received from ships have been continued to keep in a database since September 2005. In this study, volume of each waste and number of ships receiving waste are forecasted for next two years using the previous data recorded between September 2005 and January 2010.

This paper aims to estimate future waste quantities and ship requirements in Haydarpaşa WAF-Istanbul using ARMA forecasting model. In this respect, wastes collected from transit ships from 2005 to 2010 were used as the preliminary data in order to predict the amount of different wastes and the number of ships required to transport such wastes.

2. MATERIALS AND METHODS

Haydarpasa WAF has an area of 1550 m² and a waste treatment capacity of 42 m³ per hour . Volume of each waste and number of ships received waste are estimated new data at the end of next 24 months using current data between September 2005 and January 2010. Twelve ships are currently serving to collect waste in Haydarpaşa WAF based on MARPOL 73/78. The collection of wastes based on Annex I, IV and V have used 10 ships which have the names of Meke Süpüren, Meke Temizler, M/T Ataberk-1, No: 20, M/T Ahsenim, M/T Gülşenim, M/T Beyzam, M/T Sema-2, M/T Erva, and M/T Kader-5. The other two ships (M/T Raşit Bey, M/T Saka-1) have been only used to collect wastes based on Annex 1. The number of transit ships accepted waste based on MARPOL 73/78 in Haydarpaşa WAF in 2006, 2007, 2008 and 2009 were 3260, 4585, 5513 and 5033, respectively. The waste collected according to Marpol 73/78 Annex I have been treated using dewatering and chemical treatment methods. Wastes included in Annex IV have discharged into sewer system in Istanbul. Furthermore, wastes included in Annex V have been sent to Odayeri and Kömürcüoda landfills in Istanbul (Dashan, 2010).

Wastes from transit ships are collected at Haydarpaşa WAF and treated using appropriate methods. The amount of total waste collected from 2005 to 2010 are presented in Table 1. Waste volume per ship and percent volume of collected waste in the similar time frame are presented in Table 2 and Table 3, respectively.

Table 1. The amount of wastes from transit ships in Haydarpaşa WAF from 2005 to 2010

The annex of MARPOL 73/78	Annual amount of waste (m^3)					
	2005[1]	2006	2007	2008	2009	2010[2]
Annex I	9515[3]	103584	74172	106880	94929	5934
(Bilge water)	3048	27929	31988	48668	35451	2037
(Sludge)	993	12132	10478	13674	13768	1209
(Slop)	5469	53764	23011	26512	37977	2615
(Waste oil)	5	509	774	1139	942	58
(Ballast)	-	9250	7921	16887	6791	15
Annex IV	7	6410	9569	12828	9189	177
Annex V	35	10731	8434	14559	15315	158
Total amount of wastes	9557[4]	120725	92175	134267	119433	6269

[1] Year. Only for four months data (September, October, November, December).
[2] Only for two months data (January and February).
[3] 9515=3048+993+5469+5.
[4] 9557= 9515+35+7.
Annex I includes regulations for the prevention of pollution by oil composed of bilge water, sludge, slop, waste oil and ballast.
Annex IV includes prevention of pollution by sewage from ships.
Annex V includes prevention of pollution by garbage from ships.

Table 2. The amount of waste collected per ship in Haydarpaşa WAF, (2010)

The annex of MARPOL 73/78	Annual volume of Waste (m^3 waste $ship^{-1}$ $year^{-1}$)					
	2005	2006	2007	2008	2009	2010
Annex I	951.5 [1, 2]	10358.4	7417.2	10688	9492.9	593.4
(Bilge water)	304.8	2792.9	3198.8	4866.8	3545.1	203.7
(Sludge)	99.3	1213.2	1047.8	1367.4	1376.8	120.9
(Slop)	546.9	5376.4	2301.1	2651.2	3797.7	261.5
(Waste oil)	0.5	50.9	77.4	113.9	94.2	5.8
(Ballast)		925.0	792.1	1688.7	679.1	1.5
Annex IV	0.7	641.0	956.9	1282.8	918.9	17.7
Annex V	2.9 [3]	894.3	702.8	1213.3	1276.3	13.2
Total	955.1[4]	11893.7	9076.9	13184.1	11688.1	624.3

[1] 951.5=304.8+99.3+546.9+0.5.
[2] $95.5=9515*10^{-1}$. (10 ships have used to collect wastes include in Annex I).
[3] $2.9=35*12^{-1}$. (12 ships have used to collect wastes include in Annex V).
[4] 955.1=951.5+0.7+2.9.

According to Table 1, the volume of waste quantities from 2005 to 2010 was fluctuated in a wide range. It is also clear that, the volumes of waste collected from transit ships include in Annex 1 were the greatest among all other Annexes. The volumes of waste collected from transit ships include in Annex 1 were in a range of 5934 to 106880 m^3. Similar interpretations can be also withdrawn from Table 2 indicating wide fluctuations for the annual volume of waste quantities collected per ship between the years of 2005 and 2010. For example, the annual volume of waste collected from transit ships include in Annex 1 has changed between 593.4 and 10688 m^3 per ship per year. As can be seen also from Table 3, the percent annual volume of total waste collected per ship was the highest in Annex 1 within a range of 79.5 to 99.6%.

The number of transit ships accepted waste based on MARPOL 73/78 in Haydarpaşa WAF in 2006, 2007, 2008 and 2009 were 3260, 4585, 5513 and 5033, respectively. In Haydarpaşa WAF, collected wastes included in Marpol 73/78 Annex I have treated by using dewatering and chemical treatment methods. Wastes included in Annex IV have discharged into sewer system. Wastes included in Annex V have sent to Odayeri and Kömürcüoda landfills (Dashan, 2010).

Table 3. The change of collected waste from 2005 to 2010 in Haydarpaşa WAF.

The annex of MARPOL 73/78	Percent volume of wastes (%).					
	2005	2006	2007	2008	2009	2010
Annex I	99.6[(1, 2)]	85.8	80.5	79.6	79.5	94.7
(Bilge water)	31.9	23.1	34.7	36.2	29.7	32.5
(Sludge)	10.4	10.0	11.4	10.2	11.5	19.3
(Slop)	57.2	44.5	25.0	19.7	31.8	41.7
(Waste oil)	0.1	0.4	0.8	0.8	0.8	0.9
(Ballast)	-	7.7	8.6	12.6	5.7	0.2
Annex IV	0.1	5.3	10.4	9.6	7.7	2.8
Annex V	0.4	8.9	9.1	10.8	12.8	2.5

[(1)] 99.6=31.9+10.4+57.29+0.
[(2)] 99.6%=9515*100*9557^{-1}.

3. RESULTS AND DISCUSSION

In the Figures, data given from September 2005 (2005, 9) to January 2010 (2010, 1) are named as current or available, while data given beyond that time are called as estimated one based on the ARMA model. There are three-lines for each estimated section of the figures. The upper lines simply indicate the upper limit of mean estimated values, and the bottom lines imply the lower limits at 95% confidence level (Dashan, 2010). The waste amounts and ships numbers for the study area were estimated with ARMA (Auto Regression Moving Average), known as one of time series analysis models (Box *et al.*, 2009), which can be also used as a tool of NCSS software (www.ncss.com) for various statistical analysis and forecasting.

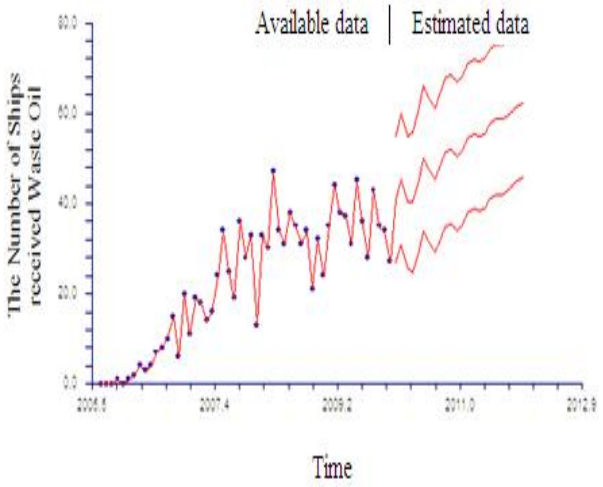
3.1 The number of ships

Time series analysis was performed using the ARMA model. The number of ships was predicted based on waste types for the time frame of February 2010 to February 2012. The data estimated are presented in the figures based on ARMA model as the results of NCSS software. The numbers of ships that have received waste oil, bilge water, sludge, slop, and ballast for both current and forecasting data were given in Figure 1a-e. As can be seen from Figure 1, the number of ships receiving waste oil, bilge water, sludge, and ballast will increase, while that receiving slop will decrease with time. It appears that the highest increase (> 55%) in the number of ships will be attained for the collection of bilge water for the two-year study period (Figure 1b). The percent increase was calculated based on subtracting the minimum ship number of 175 for February 2010 from the maximum ship number of 274 for January 2012 and then dividing the remaining by the

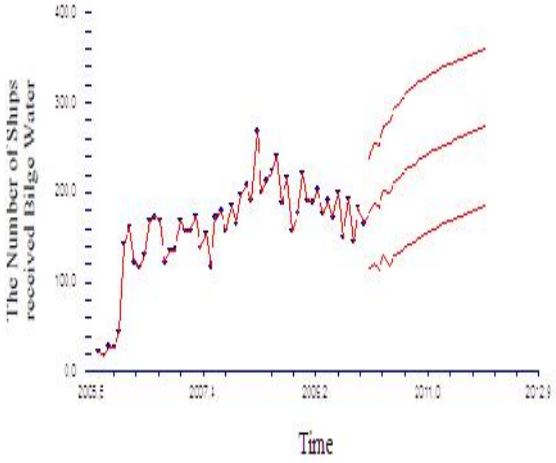
initial or minimum value of 175. The final value was multiplied by 100 in terms of reporting the result in percentile. Similar percent calculations were also made for the ship numbers receiving the other wastes. The second highest increase in the number of ships was obtained for the waste oil collection. As shown in Figure 1a, the minimum and maximum number of ships taking waste oil as mean are estimated to be 41 and 63, respectively corresponding to about 54 increase within the two-year time period. Moreover, the number of ships receiving sludge as mean will be in a range of 110-164 from February 2010 to January 2012 referring to 49% increase on that of receiving sludge at Haydarpaşa WAF (Figure 1c). Similar interpretations can be also made for the number of ships receiving ballast. The percent increases in the number of ships taking ballast between this two-year time frame was around 20% which is considerably lower than those obtained for waste oil, sludge and bilge water (Figure 1e). It is difficult to conclude that the increases in ballast collection is less significant compared to those for the other wastes, since the number of ships receiving ballast was only 5 and 6 for February 2010 and January 2012, respectively which might be considered as a limited data to make a comprehensive statistical interpretations. The only decrease on the number of ships regarding the estimated data was observed for the collection of slop. As shown in Figure 1d, the number of ships taking slop as a waste decreased from 32 for February 2010 to 15 for November 2010.

3.2 The volume of wastes

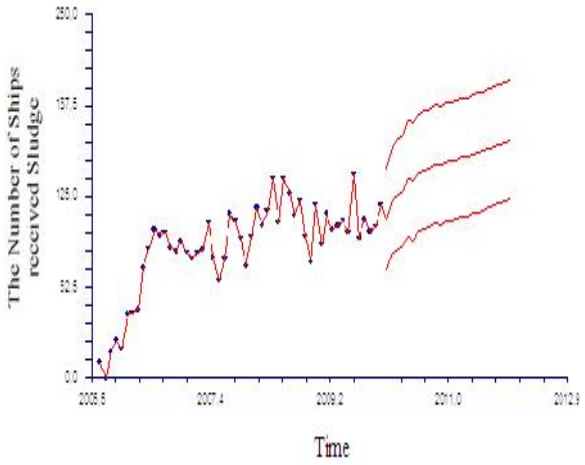
In this section, time series analysis were performed for the total amount of each waste collected by transit ships using ARMA model as the results of NCSS software. The previous data from September 2005 to January 2010 for Haydarpasa WAF were used in the model. The volumetric amount of wastes were estimated for the two-year time period. The volumetric amount of waste oil, bilge water, sludge, slop, ballast and garbage obtained from transit ships for both current and forecasting data were given in Figure 2a-f. According to Figure 2a, the amount of waste oil will increase based on time. The lowest and the highest amount as mean are estimated 72.3 m^3 on February 2010, and 133.4 m^3 on January 2012, respectively. According to Figure 2b, the amount of bilge water will increase based on time. The lowest and the highest amount as mean are estimated 2481 m^3 on February 2010, and 4585.1 on January 2012, respectively. According to Figure 2c, the amount of sludge will also increase based on time. The lowest and the highest amount as mean are estimated 970.8 m^3 on February 2010 and 1607.8 m^3 on January 2012, respectively. According to Figure 2d, the amount of slop will decrease based on time. The lowest and the highest amount as mean are estimated 2161.1 m^3 on January 2012, and 5391.5 m^3 on March 2010, respectively. According to Figure 2e, the lowest and the highest amount of ballast as mean are estimated 808.9 m^3 on February 2010, and 989.8 m^3 on January 2012, respectively. According to Figure 2f, the amount of garbage will increase based on time. The lowest and the highest amount as mean are estimated 429 m^3 on February 2010 and 1360.2 m^3 on January 2012, respectively. It can be interpreted from data in both Figure 1 and 2 that the estimations for the number of ships receiving waste are comparable with those for the total volumetric amount of such corresponding waste. As can be seen from Figure 2, the amount of waste oil, bilge water, sludge, or garbage is in an increasing trend, while those for slop and ballast decrease with time. Current data obtained from Haydarpasa WAF and estimated data obtained with ARMA model using NCSS software are compared for February, March and April 2010. It seems that the current data remains between the upper and the lower limit values of the estimated data.



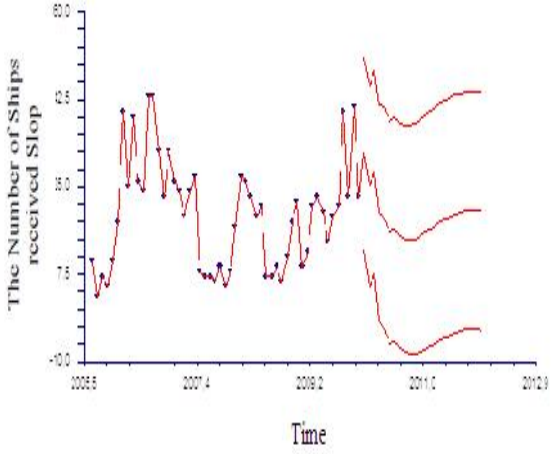
(a)
The values in vertical axis (0 to 80)



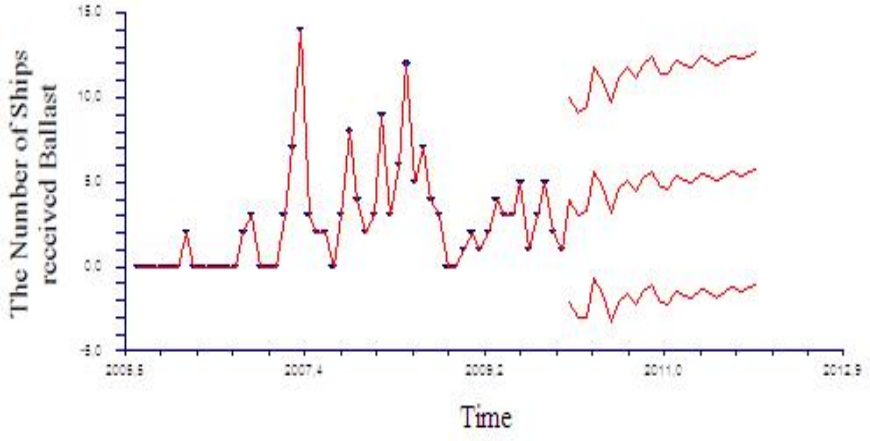
(b)
The values in vertical axis (0 to 250)



(c)
The values in vertical axis (0 to 250)

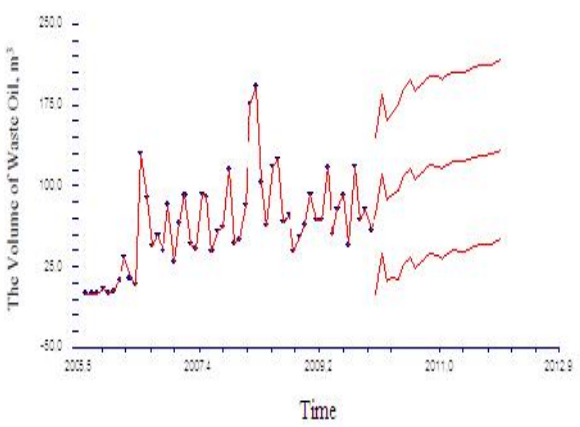


(d)
The values in vertical axis (-10 to 60)



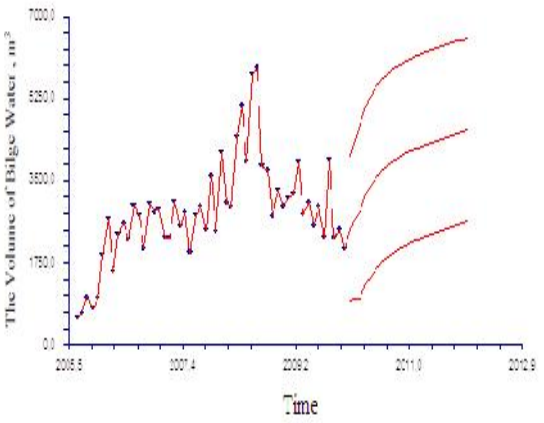
(e)
The values in vertical axis (-8 to 15). The values in horizontal axis (May 2005 to January 2010)

Figure 1. Number of ships receiving waste oil (a), bilge water (b), sludge (c), slop (d), ballast (e). The range of current data from September 2005 (2005, 9) to January 2010 (2010, 1). The range of estimated data from February 2010 (2010, 2) to February 2012 (2012, 2).



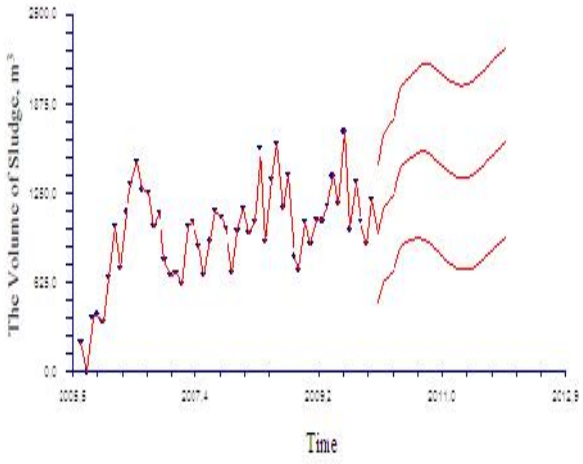
(a)

The values in vertical axis (-50 to 250 m^3)



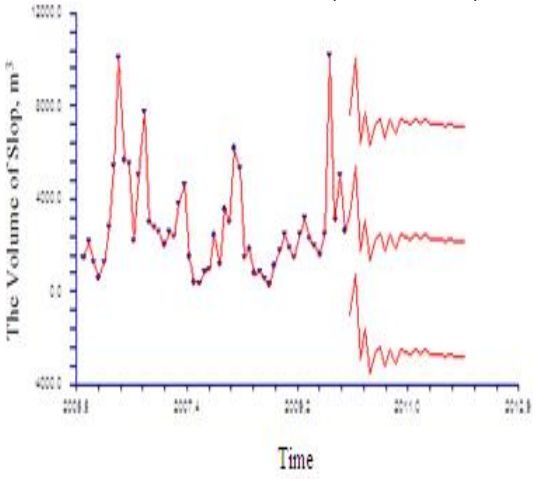
(b)

The values in vertical axis (0 to 7000 m^3)



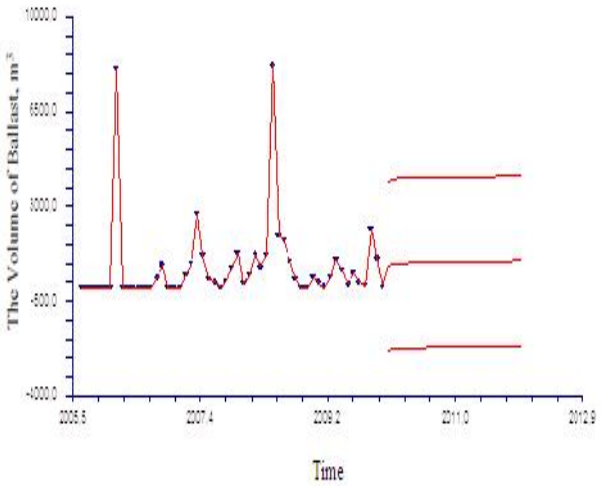
(c)

The values in vertical axis (0 to 2500 m^3)



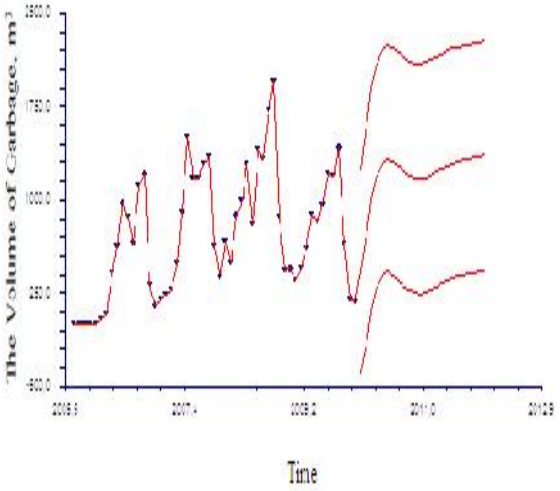
(d)

The values in vertical axis (-4000 to 12000 m^3)



(e)

The values in vertical axis (-4000 to 10000 m^3)



(f)

The values in vertical axis (-500 to 2500 m^3)

Figure 2. Volumes of the wastes received from transit ships: waste oil (a), bilge water (b), sludge (c), slop (d), ballast (e), garbage (f). Current data range from September 2005 (2005, 9) to January 2010 (2010, 1). Estimated data range from February 2010 (2010, 2) to February 2012 (2012, 2).

4. CONCLUSION

The acceptance of waste has been done at Haydarpaşa WAF since on September 2005. Waste acceptance has done based on MARPOL 73/78 (Annex I, Annex VI and Annex V). Data about number of ships and volumes of wastes from transit ships are continued to keep in a database since September 2005. According to results obtained from the database, total volume of waste collected by ships increased from 2005 to 2006 and from 2008 to 2009, but decreased from 2006 to 2007 and from 2009 to 2010. The total volumes of waste collected by per ship were obtained 955.1 m^3 $ship^{-1}$ $year^{-1}$ in 2005, 11893.7 m^3 $ship^{-1}$ $year^{-1}$ in 2006, 9076.9 m^3 $ship^{-1}$ $year^{-1}$ in 2007, 13184.1 m^3 $ship^{-1}$ $year^{-1}$ in 2008, 11688,1 m^3 $ship^{-1}$ $year^{-1}$ in 2009, and 624.3 m^3 $ship^{-1}$ $year^{-1}$ in 2010.

According to estimations figured out by NCSS software; the collected amount of waste oil, bilge water, sludge, and garbage will increase, while those for ballast and slop will decrease based on the estimated data of February 2010 to January 2012. The volumetric amount of wastes was estimated for the two-year time period. The volumetric amount of waste oil, bilge water, sludge, slop, ballast and garbage obtained from transit ships. It appears that the highest increase in the volumetric amount of waste will be attained for the collection of garbage (>68%) for the two-year study period. The predicted data indicates that the type of waste is important for its future collection rate by transit ships at Haydarpaşa WAF. This might be related with the consumption rate of their original raw materials. It seems that the collection of some waste will be in an increasing trend as time goes by due to population rises and improvements in life standards.

The results of this study might be a use for some public and private organizations conducting new WAF planning studies. Although the results of this study indicated that the model can be suitable to determine waste quantities and ship requirements at Haydarpaşa WAF for the next two-year period, a more comprehensive work is recommended to predict the future values of these parameters for extended time ranges.

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