Evaluation of Izmir bay's pollution, sources and abatement techniques

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Abstract: The largest natural bay of Turkey, the İzmir Bay on the Aegean has undergone intense pollution since 1960. Pollution sources range from industrial to urban to agricultural. In this study, sources of pollution are studied within the larger context of geographical and climactic conditions. The impact of the İzmir Great Channel Project and the Çiğli Wastewater Treatment Plant are studied. The surface sediment samples collected from the Bay were analyzed by flame atomic absorption spectrometry. Acidity was measured in the Bay by pH meter. Ways to further improvement and avenues for future research are suggested.
Keywords: İzmir Bay, pollution, heavy metal.

Introduction

Industrialization, population growth and unplanned urbanization in developing countries lead to rapid depletion and/or pollution of natural resources. Bay of İzmir is a typical example. Environmental pollution in the Bay of İzmir coastal zone has lead to eutrophication and consequential oxygen depletion in the lagoon, particularly around urban centres, resulting in increased fume, slurry, waterborne diseases and decreased fish reproduction and.

Problems of İzmir Bay are not unique. Numerous bays and gulfs have suffered similar histories. Generally the cost of pollution removal exceeds the financial reach of industries which are responsible for it and thus the challenge of bay pollution is an ever growing concern. The following cases may be quoted as examples.

Households, areas of farmland and businesses discharge their wastewater to Chesapeake Bay through regional sewage treatment plants, directly into rivers and streams. The U. S. National Oceanic and Atmospheric Administration estimate that 20% of the water entering the Bay at any one time is wastewater from industry and sewage treatment (Davison *et al*., 1997). Thomas et al. examined the linkages between the environmental quality of the Bay and the health of people and presents a framework for a public health report card for the Bay (Burke *et al*., 2000).

The pollution problems in Thailand Gulf were classified in the four groups; namely, untreated municipal and industrial water, eutrophication, trace metal contamination and finally petroleum hydrocarbon (Cheevaporn & Menasveta, 2003). Pollution in the similar form is observed in the Gulf of Guinea. A pollution sources assessment was undertaken by six countries in the region as a first step in defining a region-wide Environmental Management Plan. Results show that households produce 90% of solid waste (Scheren *et al*., 2002). On the other hand marine environmental quality in Fandy Bay, Atlantic Canada can be monitored by means of bioindicators (Chou *et al.,* 2003). PAHs, PCBs, DDTs and heavy metal contamination histories of the Mississippi River Delta, Galveston Bay and Tampa Bay sediment cores were investigated (Santschi *et al*., 2001).

The relationship between the physical features and pollution in İzmir Bay was previously studied (Sayın, 2003). Sediment distribution and net sediment transport in the Bay

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are available (Duman *et al*., 2004). Eutrophication and nutrient limitation, before and after wastewater treatment plant were monitored and reported (Kontas *et al*., 2004). A study of the influence of chronic pollution on trace metal levels in small tidal Mediterranean bays (Dassenakis *et al*., 1996) is also relevant to İzmir Bay.

In this research, contaminants causing pollution in the Bay of İzmir are classified. Water supplies and climatic conditions are examined. Great Channel Project and Çiğli wastewater treatments plants are evaluated and new solutions and suggestions are put forth as a possible basis for future studies.

Izmir bay and pollutants

İzmir Bay located in the west coast of Turkey, has an L shape. The Bay consists of three regions labeled internal, mid and external bay. Recently rapid industrialization and community development have exerted considerable stress on the Bay environment. The pollution parameters in the Bay can be prioritized according to the following categories;

a) domestic wastewater,
b) industrial wastewater,
c) raining contaminants,
d) synthetic and natural fertilizers,
e) harbor and marine transporter contaminants,
f) atmospheric pollutants,
g) eutrophication.

Figure 1 shows the complicated interaction of pollutants, the environment of İzmir Bay.

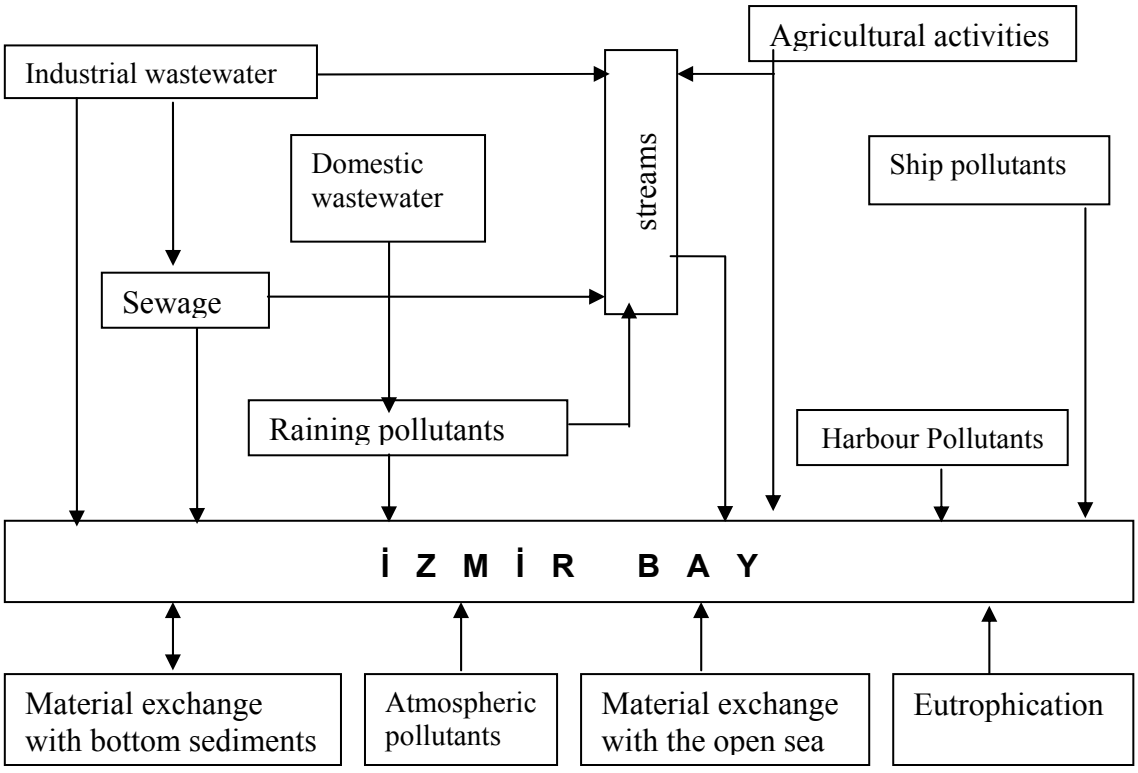

Figure 1. Interaction of pollutants with İzmir Bay.

Domestic wastewater of three million people was discharged to the Bay through sewage. Industrial wastewater was also released into the Bay. Acidic rain, synthetic and natural fertilizers and other agricultural chemicals deposited into the Bay by means of surface and drainage are additional important pollutants. Wastewater from the harbor and marine

transportation led to further pollution. Gas emissions from the nearby industry, buildings and vehicles are also pollution sources.

Under the effect of a Mediterranean climate, İzmir has warmer winters and hot summers. This leads to higher metabolic activity and a rapid consumption of dissolved oxygen; leading finally to eutrophication.

Distribution of pollutants sources affecting İzmir Bay are presented in Table 1. The most important pollution source is wastewater with equal contribution from domestic and industrial sources.

Table 1. Contribution of pollutants affecting İzmir Bay.

Pollutant supply	**%**
Domestic and industrial	50
Streets and roads	15
Streams	10
Agricultural activities	10
Soil erosion	8
Marine traffic and shipyards	4
Other	3
TOTAL	100

As seen in Table 2, stream pollutants have a larger impact on the Bay compared to sewage pollution. Cadmium and lead which mostly originate from sewage are the two exceptions. Agricultural chemicals washed into the sea by rain water are important causes of oxygen depletion.

Table 2. Pollution loads of İzmir sewage and streams

Parameter	**Sewage**	**Streams**	**Total**	**Sewage, %**	**Streams, %**
Flow rate (10^6 m^3/year)	188	732	920	20.4	79.6
COD (ton/year)	110,000	280,000	390,000	28.2	71.8
BOD (ton/year)	29,000	122,000	151,000	19.2	80.0
Suspended solid matter (ton/year)	20,000	87,000	107,000	18.7	81.3
NH_3^+ -N (ton/year)	6,800	16,700	23,500	28.9	71.1
NO_2^- -N (ton/year)	51	136	188	27.1	72.9
NO_3^- -N (ton/year)	381	1,052	1,433	26.6	73.4
Total N (ton/year)	7,232	17,888	25,121	28.7	71.3
Total Phosphor (ton/year)	488	820	1,308	37.3	62.7
Cadmium (ton/year)	0.699	0.218	0.917	76.2	23.8
Copper (ton/year)	3.420	23.860	27.280	12.5	87.5
Lead (ton/year)	8.060	4.985	13.045	61.8	38.2

Industrialization is growing in Bornova and Kemalpaşa suburbs. COD values in industrial wastewater are higher than in domestic wastewater. Some industrial wastewaters contain phenol, cyanide, heavy metals and micropollutants. Industrial wastewater generally contains nutrient agents such as nitrogen and phosphorus at low concentrations, and colloidal and suspended agents at higher concentrations. High concentrations of nitrogen and phosphorus in domestic wastewater cause eutrophication. The wastewater with heavy metal pollution tends to be acidic and toxic, with low BOD and inorganic characterization.

İzmir is an important export terminal. Marine traffic increases pollution of the Bay through waste, balance and black water. Marine accidents leading to oil leakage and contaminants are rarer but not unusual.

Suspended solid matter results in turbidity and blocks sunlight. Organic agents, supplying food to microorganisms which in turn, through their faster than normal growth lead to additional turbidity.

Izmir great channel project

The Great Cannel Project is consists of five main units: 1) A 65 km long Bay surrounding line; 2) 95 kilometres of main and branch collectors; 3) 2000 km of sewage system; 4) four pump stations and 5) a waste water treatment plant. Nitrogen and phosphorous compounds together with organic agents are removed in the biological pools with a fine bubbled diffuser system.

İzmir wastewater treatment plant was built on an area of 300 000 m^2 in Çiğli-Tuzla. The plant is of the long aired oxidation pool system with presedimented, anaerobic biophosphor pool for the removal of nitrogen and phosphorus. Slurry contains 1,46% (w/w) dry matter. The plant uses 1,563 kg polyelectrolyte per day at full capacity. After conditioning, dry matter in the slurry increases to 6% (w/w). Filterpressing increases this ratio to 30% (w/w). Filtered slurry is than stabilized by lime and transferred to its storage area.

Results and Discussion

İzmir Great Channel Project has played an effective role on the cleaning of the Bay. The before-after values for mean annual pH are 7.65 and 7.04 respectively. The leading alkaline pollutants originate from Melez and Arap streams which must be dealt with in the near future.

Table 3 displays heavy metal concentrations (determined by flame atomic absorption spectrometry) from sediment samples taken during July 2003 and these are compared with the1990 values.

Table 3. Comparison of heavy metal concentrations of sediment samples as mg/kg dry matter at İzmir Bay: July 2003 and 1990.

Metal	**Cd**		**Cr**		**Hg**		**Pb**		**Zn**	
Year	1990*	2003	1990*	2003	1990*	2003	1990*	2003	1990*	2003
Harbor	0.32	0.54	99	295	1.72	0.81	78	110	102	286
Inner Bay	0.32	0.33	55	201	1.67	0.60	78	78	81	111
Middle Bay	0.24	0.05	26	178	1.66	0.38	36	61	14	86
Outer Bay	0.50	0.04	31	130	1.67	0.51	56	48	45	67

* Uslu, 1995.

The comparison shows an increase of cadmium in the harbor and inner Bay regions, and a decrease in the middle and outer Bay. Chrome and zinc concentrations increased throughout the Bay. Mercury has decreased significantly at all regions. Lead concentrations have slightly increased in all regions except the external Bay. The concentrations of elements showed significant differences between harbour, inner middle and outer bays with higher concentrations in the inner Bay. This result was also reported by Atgin (Atgin, 2000). Although the Bay pollution has generally improved, heavy metal concentration in the Bay has not shown an appreciable improvement since these metals are not treated in the Çiğli wastewater plant. These heavy metals must be removed from the slurry and treated with lime. Thus, pathogenic microorganisms can be eliminated and slurry can be used as a fertilizer after composting. Some of the treated wastewater might be used in agriculture. Experience from USA, Germany, and Indian leads us to conclude that non-treated wastewater and slurry should not be put to agricultural use.

Another source of pollution in İzmir Bay is the marine traffic. Environmental laws forbid discharging of ballast water, wastewater and black water from ships. Violation leads to fines calculated on a gross-ton basis. However wastewater of freight ships, tankers and passenger vessels vary greatly in their polluting effects and fining them on a gross-ton basis does not make much sense. Fines based on polluting impact must be instituted. Marine traffic pollution control activated and control teams sent to ships if there is a complaint or some basis for suspicion. A more effective process of control must be instituted; shortcomings of the control teams determined and alleviated and their technical capabilities and skills upgraded.

As a result of positive developments numbers of fish and fish species in the Bay have increased. The persistence of heavy metal pollution is an ongoing concern. Support for wasteless and minimum waste technologies, controlling pollution at the source, development of recycling technologies and changes in the legal environment towards a "polluter pays" understanding will accelerate the solution of the pollution problem.

Conclusion

The Great Channel Project and the Çiğli treatment plant have made important contributions toward solving the pollution problem of İzmir Bay. Further improvement is expected to arise from treatment of heavy metal pollution. This step will lead to further economic benefits as sediments could than be used as fertilizer after composting and the wastewater could than be utilized in agriculture. Increase in marine products will benefit the ecology and economy as well.

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