A critical assessment of the Kishon River Masterplan Report published by the State of Israel Ministry of Environment, July 2001

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1. Introduction

The River Kishon, which flows into the Mediterranean Sea north of the Israeli city of Haifa, has been devastated by the wastes that are directly discharged into it from industrial and municipal sources. In recent years, the river has not been able to support life due to this pollution. The Israeli Ministry of the Environment (MoE) are presently evaluating ideas in an attempt to rehabilitate the river so that it can sustain life again, and ultimately restore a functioning ecosystem. The suggested plan involves imposing regulations that will require the industries in question to improve their technologies and in so doing reduce the toxicity of their waste discharges. The plan also involves the possible building of a pipeline that will take the waste discharges directly into Haifa Bay and in so doing bypass the river completely.

However, Haifa Bay is already suffering contamination from pollution inputs via the Kishon Estuary. Both the physical construction of a pipeline into the bay and the subsequent discharges of contaminated industrial effluents into the bay pose direct threats to the ecosystem of Haifa Bay. As a consequence of adverse impacts on the ecosystem, the local fishing industry would also suffer.

This report seeks to provide an overview and a critique of a report commissioned by and published by the Israeli MoE in July 2001 on the above-described plan to rehabilitate the River Kishon. This report also provides an alternative viewpoint and approach to the problems currently faced by the environment in the vicinity of the River Kishon.

2. The ENVIRON Report

2.1 Background

The Israeli MoE has developed a Master Plan to rehabilitate the River Kishon. Within this plan, the main options being contemplated are technological measures including additional wastewater treatment and the construction of a marine outfall. It is proposed that this new pipeline would divert treated industrial wastes directly into Haifa Bay instead into the River Kishon, as is currently the case. New regulatory standards are also discussed for the six major industries currently discharging into the River Kishon. The standards are the best available technology (BAT) limits, as provided for by the Israeli legislation ("Ordnance for the Prevention of Marine Pollution from Terrestrial Sources" (1990).

The Israeli Ministry of Environment (MoE) have commissioned a report by an Environmental consultancy (ENVIRON) to assist with the evaluation of the proposed options for the rehabilitation of the Kishon River (MoE 2001).

2.2 Aims of the Report

The aim of the ENVIRON report was to carry out a critical review of the masterplan for rehabilitation of the River Kishon and to propose action to be taken by polluting industries (MoE 2001). In so doing the report discusses:

- new permits (regulatory standards) that are recommended to control the quantity of contaminants permitted to be discharged into waste effluents of the industries in question;
- recommendations of technological improvements needed to be fulfilled by the industries in order to comply with the new regulatory standards;
- current inputs of contaminants from the industrial discharges and sewage and the potential impacts on the River Kishon and Haifa Bay;
- predicted levels of contaminated discharges following the proposed implementation of new regulatory standards;
- predicted subsequent impacts on the River Kishon and Haifa Bay of the industrial waste effluents if discharged by a pipe at a distance of 2.5 km or 5 km offshore and;
- zero discharge.

2.3 Content and recommendations of the ENVIRON Report

2.3.1 New regulatory standards

The ENVIRON report reviewed information on water quality standards (WQS) which are used in different areas of the world as well as BAT limits. It considered which of these standards would be the most appropriate for regulation of contaminated discharges from the main industries at the site of the River Kishon.

The report recommends the use of water quality standards - Environmental Quality Objectives (EQO), Environmental Quality Standards (EQS) as well as BAT limits to derive discharge limits for the industries.

The report recommends specific technological improvements that were considered to be appropriate for the industries in order for them to comply with new regulatory standards.

2.3.2 State of knowledge about contaminant discharges and associated environmental problems

The ENVIRON report summarises the state of knowledge of current inputs to the Kishon River and the degree of contamination of the Kishon River and Haifa Bay. The discussion in the ENVIRON report on the contamination of both the Kishon River and Haifa Bay is based upon data up to 20 years old, as summarised in Boxes 1 and 2. The lack of more current data seriously undermines many of the conclusions drawn on the current state of these water bodies.

A. River Kishon

The ENVIRON report notes that current Israeli regulatory standards for a wide range of pollutants are not met by present industrial discharges into the river. The regulatory limits are violated by all six of the industries. Violations occur for both maximal and average concentrations of pollutants, including nitrogen compounds, phosphate, heavy metals, detergents, mineral oils, as well as biological oxygen demand (BOD). The report therefore clearly shows current failings by all of the six industries to treat their wastes to the standards required by current legislation. The proposal of new, more stringent, standards will not provide the necessary environmental protection if they are not effectively policed.

Box 1; River Kishon

The ENVIRON report outlines the current situation with regards to the River Kishon, which is currently a brackish waterway with a "non-functioning ecosystem" due to the ongoing discharges of effluents containing pollutants including persistent and toxic chemicals. At present, the Kishon River receives sewage discharges from the Haifa municipal Waste Water Treatment Plant (WWTP) as well as industrial wastes from six major sites; Deshanim (Fertiliser and Chemicals), Gadot Biochemicals, Carmel Olefins, Haifa Oil Refinery, Haifa Chemicals & Gadiv Petrochemicals (MoE 2001).

As a consequence of the industrial discharges into the lower part of the river, its waters and sediments are contaminated with a wide range of chemicals including toxic metals and organic chemicals of petrochemical origin. Furthermore, effluents are discharged that contain high levels of nutrients and degradable organic matter resulting in such serious dissolved oxygen depletion that few forms of life can survive. In parts of the river the water is also highly acidic, primarily due to discharges from Haifa Chemicals.

The Kishon sediments contain extremely high levels of fluorite (CaF_2) due to industrial discharges, making up as much as 70% of the sediment at some locations. The levels of many heavy metals, including zinc, copper and cadmium are significantly elevated. Levels of these metals increase downstream due to the high water acidity. The report recognises that sediment levels of heavy metals have increased since the early 1970s, demonstrating their accumulation as a result of continuous discharge.

The sediments are also contaminated with organic pollutants, consisting primarily of petroleum components. Again this demonstrates the impact of ongoing industrial waste effluents to the river, presumably due mainly to the three petrochemical industries.

B. Haifa Bay

The water, sediments and biota (living creatures) in Haifa Bay are contaminated by inputs of pollutants from the Kishon estuary as a direct result of industrial discharges to the river, and by discharges by other nearby industries (MoE 2001).

According to the ENVIRON report, there is ongoing eutrophication of the bay due to pollutant input from the estuary especially in the southern part of the Bay. The benthic (bottom-dwelling) sea creatures were reported to be impoverished at a distance of 1.2km offshore, but from 1.2 to 5 km there is a diverse and abundant array of plant and animal life.

The statements made in the ENVIRON report that "the concentration ranges in the bay were in all cases not significantly higher than levels found at the control stations" and the conclusion that the "biota of Haifa Bay is currently not significantly contaminated by copper, zinc, lead or cadmium" are not consistent with the data given.

Furthermore, the ENVIRON report draws conclusions on the levels of contamination by metals in the biota of Haifa Bay based upon data obtained from samples collected prior to 1988, as given in Section 5.3.3 of the ENVIRON report. Such interpretations fail to take into account changes that may have occurred in the subsequent years. As metals are persistent and tend to accumulate in both sediments and biota (see Boxes 3 & 4), the situation may now be worse than indicated in the report.

Box 2; Haifa Bay

Water

The report by ENVIRON notes that the waters of Haifa Bay contain:

- high phosphorus levels especially near to the Kishon Estuary
- high inorganic nitrogen, generally near the Kishon Harbour
- plankton blooms in certain areas, most likely due to discharges of nutrients

Sediments

The report by ENVIRON noted that sediments in Haifa Bay contained heavy metals but levels were not significantly elevated. However, the entire bay has been reported to be enriched with lead and to a lesser extent with zinc and copper. Furthermore, levels are mercury were highest close to the outfall from the EIL chlor-alkali plant. Mercury contamination extends to about 1km into the bay. Levels at the most highly contaminated sites were reported as about 1mg/Kg. The ENVIRON report commented that levels of 1 mg/Kg were moderate compared to areas with heavy industrial pollution. This level is, however, elevated compared to normal background levels in sediments (0.02-0.1 mg/Kg) (WHO 1989).

Biota

Tabulated data given in Section 5.3.3 of the report by ENVIRON indicate small but significant elevations of heavy metals in hermit crabs. Maximum concentrations of cadmium, lead and mercury in some other species were elevated several times above levels found in control areas.

The elevated levels of metals reported for biota in Haifa Bay suggests impacts from the anthropogenic sources of these metals. The ENVIRON report noted that there was lack of significant correlation of heavy metals levels in biota with sediment concentrations. This may reflect multiple uptake routes of these metals from metals within the sediments, the overlying water and diet.

Mercury contamination was found in biota from Haifa Bay. The ENVIRON report acknowledged that a correlation existed between the mercury content in biota and in levels in sediments. It also noted that no systematic decrease in the mercury content of *Arcularia gibbosula* (a shellfish) occurred between 1980-1987, despite the installation of waste treatment facilities at the major source to the bay, the EIL chlor-alkali plant, around 1984. Furthermore, while levels of mercury in some species have decreased within the bay, the ENVIRON report gave data which showed that levels in biota collected close to the plant remain higher than the same species collected along the coast.

2.3.3 Predicted state of pollution with implementation of new regulatory standards.

As discussed above, the ENVIRON report makes recommendations on the new regulatory standards that should be adopted and briefly on suggested technological improvements industries should make to comply with these regulatory limits.

Should the discharges from all six listed industries meet the set permit values given in Appendix F of the report, considerable quantities of pollutants would still be discharged, as detailed in Table 1.

Pollutant	Total allowable discharge quantity (Kg/year)
Ammonia (NH_4)	72434
Detergents	9673
Mineral oils	4344
Chromium (Cr)	593
Cadmium (Cd)	237
Copper (Cu)	712
Iron (Fe)	7118
Mercury (Hg)	27
Nickel (Ni)	475
Lead (Pb)	475
Vanadium (V)	712
Zinc (Zn)	2373

Table 1. Total quantities of pollutants allowed to be discharged by the six industries listed in the River Kishon Masterplan Report, based upon the BAT permit limits as detailed in Appendix F of the report (MOE 2001)

Even after the suggested short-term technological improvements have been made, however, it is still predicted that not all regulatory limits will be achievable. Levels of suspended solids (SS), chemical oxygen demand (COD), nitrogen compounds, phosphate, detergents, BOD and salinity are all predicted to remain in excess of new limits even after technological improvements by the industries recommended by ENVIRON. This is illustrated by the list below which shows constituents of industrial waste effluents that are predicted to violate the new limits even after technological improvements by the industries (taken from section 3.9, MoE 2001):

Haifa Chemicals: BOD, SS, detergents
Haifa Oil Refineries: possibly COD, SS, ammonia
Carmel Olefins: possibly detergents, mineral oils
Fertilizers and Chemicals (Denshanim): Nitrates, phosphate, detergents
Gadiv: discharges may still exceed sea limits
GADOT: nitrogen compounds, phosphate.

If the suggested technological improvements to the industrial waste treatment of the six industries were implemented, the report noted that predictions using a mathematical model (MIKE12) suggested that two industries (Gadiv Petrochemicals, Carmel Olefins) could probably discharge their wastes into the River Kishon. However, the model suggested that the other polluters, including Haifa municipal sewage treatment plant, would need to direct their wastes directly to Haifa Bay if the river is to recover. Another important point was made, which was that even with the diversion of effluents from the industries, river quality may still be adversely affected by rainfall run-off from the industrial sites, run-off from a gypsum stack located on the Deshanim site and possible leachate from the municipal landfill.

3. The proposed pipeline into Haifa Bay

The report by ENVIRON documents impacts on Haifa Bay that are predicted to occur from both the physical construction of a proposed pipeline and from its polluted industrial waste discharges. These are given below. The report assessed the impacts of a pipeline proposed to discharge industrial waste either 2.5 km or 5.0 km offshore.

3.1 Impacts of construction of a pipeline

The ENVIRON report recognises a number of important issues relating to the ecology and human uses of Haifa Bay:

- The rocky Kurkar ridges located 1.2-5km offshore are an area of unique habitat of diverse and abundant flora and fauna and are of great scientific interest;
- The Kurkar ridges are extremely important to commercial fisheries, including important species of both crustaceans and fish;
- The bay acts as a nursery ground for the fish *Sardinella aurita*. Many demersal (bottom-dwelling) fish species that are caught locally are probably also hatched in Haifa Bay;
- Haifa Bay is important for trawl fishing. It has been the area of highest yield per unit effort along the Israeli coast. In the past decade Haifa Bay fishermen caught almost 50% of the annual yield of inshore fishery catches from the Israeli coast.

It is of concern to note that the ENVIRON report comments that data available for the specific locations of the proposed pipeline outlets is "extremely limited". According to the ENVIRON report, the physical construction of a pipeline might affect reef habitats and the Kurkar ridges which, they themselves acknowledge, are important as fishery habitats and in terms of their nature conservation value. It is clear that construction of a pipeline would threaten both the ecology of Haifa Bay and also its local fishing industry.

3.2 Impacts of effluent discharges from a proposed pipeline into Haifa Bay

A 1996 study, reviewed by the ENVIRON report, used a mathematical model to attempt to predict the impacts of discharging industrial effluents from the pipeline proposed for Haifa Bay. The study used figures based on current levels of contaminants in discharges from the industries in question. The ENVIRON report assessed the results of this study. Further work using the model with levels of contaminants in discharges predicted after the implementation new regulatory BAT permit is currently underway but is incomplete.

From the modelling studies, the ENVIRON report concludes that:

- The loadings of nickel and zinc would exceed limits for water quality in the area called the near-field mixing zone which is located in the vicinity of the discharge outfall. Other heavy metals were predicted to meet water quality standards;
- Nutrient levels (eg. nitrogen compounds) would be expected to decrease within the harbour of Haifa Bay, where eutrophication is currently apparent. However, nutrient concentrations would be greater in the northern parts of Haifa Bay from pipeline discharges. Moreover, modelling research to predict eutrophication

effects showed that a pipeline located at either 2 or 5 km offshore would lead to "a slight enhancement of phytoplankton production beyond the Haifa Harbour area".

The modelling studies therefore showed that water quality standards for certain heavy metals are not met in the near-field mixing zone and that eutrophication effects would become apparent in the bay. The ENVIRON report noted that further detailed marine ecological surveys should be carried out to assess ecological impacts from the proposed pipeline.

The ENVIRON study did not mention either the possible impact of a pipeline discharge in Haifa Bay on levels of toxic contaminants in biota and subsequent biological impacts on the biota or implications for fish consumed by humans. For instance, toxic chemicals which are persistent and bioaccumulate would be present in the discharges. These include heavy metals and polycyclic aromatic hydrocarbons (PAHs). One of the chemicals predicted to be high in the discharges was nickel, a metal that is significantly bioaccumulated in some aquatic organisms including marine phytoplankton and seaweeds (ATSDR 2000).

If levels of such toxic contaminants adversely affected the ecology of Haifa Bay, this could result in significant impacts on the size and quality of catches by the local fishing industry. Furthermore, demersal (bottom dwelling) fish tend to accumulate sediment bound toxic chemicals more than pelagic species. Where such pollutants, such as mercury, have the ability to bioaccumulate, human consumption of these species can result in a higher human intake of these pollutants with potentially damaging health effects (WHO 1989).

4. Critique of the ENVIRON Report.

The ENVIRON report concludes that a pipeline is essential for the recovery of the river. Yet, at the same time, it clearly lists threats to the environment of Haifa Bay and its fishing industry from the construction and discharges from the proposed pipeline.

This ENVIRON report effectively seeks a solution to the current situation of the River Kishon by comparison of current pollution impacts with those of a limited number of alternatives, largely the construction of a marine discharge outfall.

However, the report fails to make an adequate assessment of the impacts resulting from the discharges since they omit some of the critical pollutants. Other critical issues including international law and pollution prevention have also not been considered. Given the omissions and inadequacies in the ENVIRON report, no credence can be given to the conclusions drawn concerning the acceptability of discharge of treated wastes into Haifa Bay.

4.1 Environmental hazards neglected by the ENVIRON Report

4.1.1 Haifa Chemicals

Haifa Chemicals produce phosphate fertilizer from phosphate rock, an ore which contains metallic and radioactive contaminants. Of the six industries, Haifa Chemicals is currently a major source of pollutants, especially for heavy metals, and acidity (low pH). Production changes have been made through changing the phosphate rock raw material source. No date is given for the date of this change, though the change must have occurred prior to September 2000 as the ENVIRON report comments in Section 4.2 that "data [for the River Kishon] for September 2000….show a substantial improvement….due to the replacement of Israeli Zin phosphate rock by Russian Kola rock as a raw material".

A. Heavy Metals

Data for 2001 presented in Annex F of the ENVIRON report indicates that the effluents still contain significant quantities of many metals, including cadmium, copper, chromium, lead and mercury, nickel and zinc.

The 2001 data shows that the average effluent concentrations of chromium, copper, lead, nickel and zinc were above their discharge limits. For chromium, nickel, vanadium and zinc, the spot-checking data presented in Table D.II of the ENVIRON report shows concentrations significantly higher than these average values (no maximum metal concentration values are quoted for effluents in 2001). Furthermore, predicted average effluent concentrations for chromium, mercury, nickel, lead and zinc are all above their respective discharge limits.

The 2001 average effluent concentration for cadmium was 0.1mg/L, equal to the discharge limit. The persistence, toxicity and ability of this metal to bioaccumulate demonstrate the need to eliminate cadmium from any discharged effluent.

Many of the metals discharged from Haifa Chemicals are toxic to aquatic organisms, and many accumulate in sediments and bioaccumulate (see Boxes 3-5). The data discussed above demonstrates the need for alternative measures to address the production of waste streams by Haifa Chemicals containing these metals.

The agricultural use of phosphate fertilisers derived from phosphate rock can dramatically increase cadmium concentrations in the soil (Cabrera *et al.* 1994, De Boo 1990). Furthermore, cadmium accumulation from soil has been reported in grasses and food crops, as well as in poultry, cattle, horses, and wildlife (ATSDR 2000, WHO 1992). Uptake of cadmium from soil by animal feed crops may result in high levels of cadmium in beef and poultry, especially in the liver and kidneys. This accumulation of cadmium in the food chain has potential implications for human exposure (ATSDR 2000).

B. Radionuclide contaminants

Phosphate rocks used for the production of fertilizers are enriched with uranium (^{238}U) and other radionuclides to varying amounts, depending on the source. The mining of phosphate rock containing radionuclides can result in increased levels of these hazardous contaminants and their decay products in the vicinity, a problem which can persist even after completion of mining activities (Orloff & Nall 1998).

Phosphate rock possessing at Haifa Chemicals uses hydrochloric acid (HCl) to extract the phosphate as phosphoric acid. The wet processing of such material, as carried out at Haifa Chemicals, can result in releases of radioactive uranium and its radioactive decay products, many of which are also radioactive. These include isotopes of radium (Ra), thorium (Th), polonium (Po) and lead (Pb) (Papastefanou 2001).

This process produces water-soluble calcium chloride ($CaCl_2$) and insoluble calcium fluoride or fluorite (CaF_2), which precipitates as a sludge. Due to the similar chemical characteristic of the radionuclide ^{226}Ra and calcium (Ca), waste streams contaminated with the radionuclide ^{226}Ra will result in discharges of soluble $^{226}RaCl_2$ unless special decontamination measures are taken, while insoluble $^{226}RaF_2$ will co-precipitate with the fluorite (Paridaens & Vanmarcke 2001). The potential consequences of the production and discharge of radionuclide contaminated wastes is demonstrated by the extremely high concentrations (70%) of fluorite in sediments in parts of the River Kishon, as shown in Table 4.4a of the ENVIRON report.

In addition to releases via water and solid waste streams, activities during phosphate rock wet processing have been shown to result in releases of radionuclides to the atmosphere in both gaseous and particulate form, including uranium (^{238}U) and radium (^{226}Ra). Such releases may result in elevated radiation exposure to human populations in the vicinity (Papastefanou 2001).

Discharges of contaminated wastes have lead to elevated levels of radionuclides in water, suspended matter and sediments of the receiving water bodies (Perianez & Martinez-Aquirre 1997, Paridaens & Vanmarcke 2001, Poole *et al.* 1995). Elevated levels of some radionuclides, including polonium (^{210}Po), have been observed in shellfish near to marine discharge points and elevated human radionuclide exposure through shellfish consumption has been predicted, in addition to the exposure of marine organisms themselves (Camplin *et al.* 1996).

Phosphate fertilizers derived from phosphate rock can have relatively high concentrations of natural radionuclides, including uranium (^{238}U) and radium (^{226}Ra) (Ioannides *et al*. 1997 & Erdem *et al.* 1996). Ongoing use of these fertilizers has been shown to cause many-fold accumulative increases in the levels of such radionuclides in treated soils (Ioannides *et al*. 1997). This constitutes a source of technologically enhanced natural radiation, increasing the total exposure of humans and other species from natural radionuclides. Elevated levels of radionuclides present as trace contaminants in the fertilizers have been found in the urine and hair of humans using the fertilizers (Santos *et al.* 1995).

Haifa Chemicals currently produce phosphate fertilizers from Russian Kola rock, a magmatic ore. While such ores generally contain lesser amounts of uranium than sedimentary ores, the radionuclide contaminants can still pose a potential problem (Papastefanou 2001).

No data is available on the extent of the radionuclide contamination of the Kola ore currently used by Haifa Chemicals. The quantity of radionuclides present in the previously used Israeli Zin phosphate ores is also not discussed. The presence of radionuclide releases that have resulted from both current processes and the historic use of Israeli Zin ore has implications for the clean-up of the River Kishon, and the treatment of sedimentary material removed from the river.

Box 3; Accumulation of Pollutants in Sediments

Many chemicals, including most toxic metals (such as cadmium, copper, lead, mercury and zinc) and many persistent organic chemicals such as PAHs tend to bind to suspended particles within the water body, often rapidly and with a very high affinity. This process is generally followed by precipitation and final accumulation of these particles in the bottom sediment (ATSDR 2000). Because of the strength with which many metals are bound to sediment, their release back to the water column is generally slight. Dredging or re-suspension of bottom sediment, for example by trawling, may cause short-term release of pollutants, although dissolved levels quickly return to pre-disturbance values.

Cadmium is more mobile in aquatic environments than most other metals. Soluble forms of cadmium may migrate in water, although cadmium can also be present as relatively immobile forms such as insoluble complexes or adsorbed to sediments. (ATSDR 2000).

Biological uptake from sediments may be a dominant pathway for uptake of certain chemicals from the aquatic environment by organisms. This is the case for example, for the metals cadmium, lead and mercury (Bryan and Langston 1992). The uptake from sediments can account for relatively high concentrations of toxic chemicals in organisms, which feed among bottom sediments in marine environments (Bryan and Langston 1992). The ability of such pollutants to accumulate in sediments as a result of their ongoing discharges, even when released in soluble form, can lead to increasing adverse effects that may not be immediately visible.

4.1.2 Discharges from industries other than Haifa Chemicals

A. Heavy metals

The effluents from the industries other than Haifa Chemicals contain mercury, albeit at low levels, as shown in spot checking data for Deshanim (Table D.II) and the average 2001 effluent data and for the remaining industries (Annex F) quoted the ENVIRON report. The concentrations for Gadiv and Deshanim are above the BAT limits of 2µg/L (0.002mg/l). For comparison, coastal seawater typically contains mercury at concentrations below 0.015 µg/L (WHO 1989). While the ENVIRON report states that the major source of mercury to Haifa Bay is from the EIL chlor-alkali plant located on Haifa Bay, these additional input will place an increased burden on the ecosystem.

In addition to mercury, the 2001 data for the discharges from Gadot (Annex F), shows the presence of a number of toxic metals including cadmium, chromium, copper, nickel and zinc at concentration above typical background concentrations found in freshwater and sea water (ATSDR 2000, Bryan & Langston 1992).

While the concentrations of these metals in the effluents are not exceedingly high, their presence is of concern due to the ability of these metals to accumulate in sediments. The presence of the highly toxic metals cadmium and mercury is of particular concern due to the ability of cadmium to bioaccumulate and of mercury to bioaccumulate and biomagnify (see Boxes 3 & 4).

B. Organic pollutants

The effluents of all six industries contain mineral oils. The predicted levels for Carmel Olefins and the 2001 figures for Gadot, for which no predicted improvement values are given, show levels above the BAT limits. The effluent spot checking data presented in Table D.I of the ENVIRON report also shows the presence of "grease and oil" in the discharges from all industries.

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals often present in petrochemical mixtures (ATSDR 2000). It is therefore likely that the mineral oils, grease and oil in the discharges contain a number of PAHs. Some PAHs are toxic and persistent and have the ability to accumulate in sediments subsequent to release to water bodies (ATSDR 2000) (see Box 3).

Permit levels are usually exceeded in practice (Allsopp *et al.* 2001). The report considers accident and pollution surges in the case of the river and stresses their dangers. However, no mention is made of this possibility when discussing discharges to Haifa Bay.

4.1.3 Chloramine

One of the products manufactured by Deshanim Fertilizer and Chemicals is the biocide trichloro-isocyanuric acid (TTCA). This chemical is produced from the reaction of sodium cyanurate with elemental chlorine (Cl_2).

The waste stream from the TTCA plant contains elemental chlorine. This waste stream is mixed with the waste stream of the liquid fertilizer plant which contains ammonia. While this process reduces the concentration of free chlorine in the effluent, it results in the production of chloramine, a highly toxic organochlorine.

Data given in the ENVIRON report confirms the presence of chloramine in the final effluent from Deshanim Fertilizer and Chemicals. ENVIRON notes that without process changes downstream of the existing ammonia-chlorine destruction unit, compliance to the discharge limit for Deshanim will not be achievable. The non-compliance, however, is only considered in terms of molecular chlorine and ammonia, and chloramine is not discussed in terms of discharge concentrations nor in measures needed to eliminate this toxic organochlorine.

In Table D.III, ENVIRON quote effluent data, which shows the presence of chloramine in varying quantities in the effluents of the other five industries. No other data for the presence of this compound in the waste streams from these plants is available. The source of chloramine in these waste streams is not clear, but may be a result of reaction between ammonia in the waste streams with chlorine added during wastewater treatment (Bull *et al.* 1990).

The addition of chlorine and chloramine to drinking water, for the purpose of drinking water disinfection, has been shown to produce a range of chemicals including toxic organochlorine compounds such as trihalomethanes (Bull 1986). Trihalomethanes exhibit a range of chronic and acute health effects, with the liver and kidney being the main target organs (Fawell & Hunt 1988). One chemical in this group, chloroform, has been listed by the US Department of Health and Human Services in its 9th Report on Carcinogens as Reasonably Anticipated to be a Human Carcinogen (USPHS

2001). Volatile organic chemical such as chloroform readily evaporate from water, enabling discharge to the atmosphere during wastewater treatment. Such releases have not been considered in the ENVIRON report. Consequently no monitoring or abatement measures are currently in place, nor are they planned.

4.1.4 Detergents

The presence of detergents in the effluents of the six industries is discussed in the ENVIRON report. The proposed limits for detergents are the same for all industries; 1mg/L monthly average concentration, with a maximum concentration of 1.5mg/L, measured as methylene blue active substances (MBAS).

The predicted detergents effluent performances for a number of industries (Carmel Olefins, Haifa Chemicals, Deshanim Fertilizers and Chemicals and Gadot) remain above the proposed limits and the concentrations in the effluent from Carmel Olefins fluctuate widely. For Deshanim Fertilizers and Chemicals, Gadot and Haifa Chemicals, ENVIRON acknowledges that the proposed limits are unlikely to be met, even after implementation of the proposed process and treatment changes.

Box 4; Bioaccumulation, bioconcentration and biomagnification

Once released to the environment, many chemicals including toxic metals such as cadmium, lead and mercury and certain organic chemicals including PAHs are known to build up in the tissues of aquatic organisms (ATSDR 2000).

Both aquatic and terrestrial organisms are known to accumulate cadmium from their diets (bioaccumulation). Studies have shown accumulation of bioavailable cadmium in aquatic animals at concentrations hundreds to thousands of times higher than in the water (ATSDR 2000).

Plants and animals can also pick up lead from water, soil and sediment (ATSDR 2000), a process known as bioconcentration. Lead can be accumulated directly from sea and fresh waters, especially in organisms that utilise gill tissue as the major nutrient uptake route (Sadiq 1992).

Biomagnification is the process whereby the concentration of a pollutant increase up the food chain. Inorganic mercury can be converted to organic forms by micro-organisms, indigenous to soils, fresh water and marine sediments. The most common form of organic mercury is methylmercury (MeHg), which is soluble, mobile and quick to enter the aquatic food chain. The selective retention of MeHg at each step in the food chain, relative to inorganic mercury, is related to its high lipid solubility, its long biological half-life and the comparative longevity of top predators (Bryan & Langston 1992). As a result, MeHg provides one of the rare examples of metal biomagnification in food chains (ATSDR 2000, WHO 1989). For example, concentrations in carnivorous fish at the top of freshwater and salt water food chains (e.g., pike, tuna, and swordfish) are biomagnified to 10,000-100,000 times the concentrations found in ambient waters (ATSDR 2000). The significance of this bioaccumulation is that it is generally the most important source of human, non-occupational mercury exposure (ATSDR 2000, WHO 1989).

Text Box 5; Toxicity

Mercury

Mercury is an extremely toxic, non-essential trace metal, having no biochemical or nutritional function. Biological mechanisms for its removal are poor, and, as mentioned above, mercury is the only metal known to biomagnify i.e. progressively accumulate though the food chain (WHO 1989). Exposure to methyl mercury (MeHg) has resulted in permanent damage to the central nervous system (CNS), kidneys, and the developing foetus (ATSDR 2000).

The problem of methylation of past and present inorganic mercury discharges continues after releases have ceased and the long retention time of mercury by sediments delays the elimination of contamination for many years (Barbosa 1997, Akagi *et al.* 1995).

Cadmium

Cadmium has no biochemical or nutritional function and it is highly toxic to both plants and animals (ATSDR 2000, WHO 1992, Alloway 1990). In humans and animals, there is strong evidence that the kidney is the main target organ of cadmium toxicity following extended exposure (ATSDR 2000, Elinder & Jarup 1996, Goyer 1996, Roels *et al.* 1993, Iwata *et al.* 1993, WHO 1992, Mueller *et al.* 1992). Cadmium and cadmium compounds are listed by the International Agency for Research on Cancer (IARC) as carcinogenic to humans (IARC 1998). The US Department of Health and Human Services in its 9^{th} Report on Carcinogens, lists cadmium and certain cadmium compounds as Known to be Human Carcinogens (USPHS 2001).

Regarding the toxicity of cadmium to aquatic organisms, numerous findings have been reported. For example, some species of phytoplankton are very sensitive to cadmium, with inhibition of growth observed at concentrations as low as 1 ug/l (Bryan & Langston 1992).

Copper

Aquatic toxicity to copper is well studied, and there is experimental evidence that a considerable number of species are sensitive to dissolved concentrations as low as 1-10 μg/l (Bryan and Langston 1992). As a consequence of the considerable toxicity of copper to many marine invertebrate species, it has long been included as a constituent in anti-fouling paints for boats.

Lead

Lead has no known, nutrition, biochemical or physiological function. It is toxic to most living things, including all aquatic biota (ATSDR 2000, Bryan & Langston 1992). Of particular concern is the damaging effect of relatively low exposure on the development of the nervous systems of both animals and humans (Pirkle *et al.* 1998, ATSDR 2000).

The data for 2000 (Table 4.1 in the ENVIRON report) shows that detergents were released to the River Kishon at a combined rate of 7.1Kg/day, which has contributed to breaches of the environmental water quality standards for the River Kishon at Histadrut Bridge (1999-2000, Table 4.2) and at Haifa port (05/09/00, Table 4.3).

In addition to these discharge breaches values, the report discusses detergents in general terms without mention of the specific types that may be present in the various wastestreams. For all data in the report, the concentrations of detergents are given as MBAS measurements, and detergents are defined as possessing "slight toxicity" (Table 2.3). The MBAS measurement essentially gives a value for the quantity of anionic detergents including linear alkylbenzene sulfonate detergents, but does not account for the presence of another group of widely used detergents, alkylphenol polyethoxylates (APEs) and their problematic degradation products (Standard Methods for the Examination of Water and Wastewater 1985).

Biodegradation of APEs during wastewater treatment or in natural environments results in the formation of alkylphenols (APs) including octyl- and nonylphenols (Bennie 1999). Octyl- and nonylphenols are compounds of concern due to their environmental persistence, aquatic toxicity and estrogen-mimicking effects, which can result in disruption to reproduction and development in a wide range of aquatic biota including fish (Bennie 1999, Servos 1999). While much of the evidence of estrogenicity is from freshwater biota, there is increasing evidence of similar effects in the estuarine and marine environments (Gray *et al.* 1999). Studies also indicate low to moderate bioaccumulation of APs and APEs in aquatic biota in the environment (Servos 1999). Furthermore, certain APEs have been shown to exhibit aquatic toxicity and estrogen-mimicking effects themselves (Servos 1999, Jobling *et al.* 1996).

Clearly the criteria covering discharges of detergents must take into account whether alkylphenol polyethoxylates (APEs) and their degradation products are present. Similarly, appropriate disposal of sludges from wastewater treatment facilities must take into account their presence.

4.2 Misuse of the word "brine"

The ENVIRON report states that the combined effluents would have a salinity and density in excess of seawater, with calcium chloride as the predominant ionic salt, and is therefore correctly defined as brine (see Sections 4.4/4.5 of the report). ENVIRON, however, recognises that all individual effluents may not be described as brine. The term "brine" is generally defined as water saturated, or strongly impregnated, with salt. In section 4.5.1, the term brine is defined solely on the quantity of chloride in the various discharges.

The discharge from Haifa Chemicals has an extremely high salinity, with a chloride content approximately twice that of seawater. It is primarily this chloride concentration that allows the combined effluents from all six industries to be described as brine under the reports definition.

The definition of brine used by ENVIRON masks the presence of toxic, persistent and accumulative pollutants in individual effluents, including certain metals, persistent detergents and their degradation products and organochlorine compounds.

4.3 Combined effluent discharge

The report concludes in Section 6.5 that "synergistic or antagonistic effects in the combined effluents are not expected". No evidence or data, however, is given in support of this statement.

The potential impacts resulting from the presence of pollutants in the effluents are based on risk assessment principles, where the impacts of each individual component in the waste stream are considered separately. This approach fails to consider cumulative impacts on organisms from multiple pollutants present at low concentrations. Such cumulative toxic effects have been demonstrated for metals and organic compounds including PAHs (Chaloupka *et al.* 1993, Sarakinos *et al.* 2000). These chemicals are present in the effluents currently discharged to the Kishon River.

Further, the combining of individual waste streams has implication with regard to effluent monitoring and the implementation of any necessary corrective measures to an individual process or waste treatment, as discussed below (Section 4.6).

4.4 Mixing zones

The report discusses the use of mixing zones, limited areas or volumes of water allowed for the initial mixing of effluents, the quality of which does not meet surface water quality standards. No definition is given for the size of these zones other than that they are sized for rapid mixing and to prevent lethality to passing organisms - this fails to consider long-term chronic impacts on the ecosystem.

As water quality standards are set to limit environmental impacts on the receiving body, the exceeding of such limits within mixing zones will result in unacceptable impacts within the zone.

The report notes that the high density of the effluent and the low ambient currents within Haifa Bay will inhibit mixing and may lead to highly damaging pooling of effluent near to the discharge point. While suggestions are made that may improve initial mixing, ENVIRON recognises that for many pollutants including cadmium, copper, nickel and zinc, the concentrations within the near-field zone of the outfall may be substantially higher than concentrations predicted by computer modelling currently completed and that sufficiently detailed modelling has yet to be carried out.

The calculation of discharge limits from water quality standards are based upon dilution and dispersion principles, assuming set dilution factors for the discharged effluent by 1:100, and 1:20 for mercury and cadmium. Any inhibition of mixing may result in significantly higher actual levels within the vicinity of the discharge location than those calculated from the discharging effluent concentrations, which may result in significant impacts.

In addition, some dissolved pollutants will rapidly precipitate or bind to suspended particles upon discharge, thus settling on the surface below the receiving water body prior to sufficient mixing. Biological uptake can occur directly from sediment bound pollutants. These processes can occur for a number of toxic pollutants present in the effluents (see Box 3).

Further, some pollutants present in the effluents can be accumulated by organisms (see Box 4). The consequences of detrimental impacts may, therefore, extend considerably beyond the mixing zone, particularly affecting biota that can move into and out of the zone, which may include fish stocks that are consumed by humans.

In light of the inherent problems with the use of mixing zones, and that the rate and degree of mixing is currently not fully understood, the size of the zones and the full extent of detrimental effects within the vicinity of the outfall cannot be reasonably predicted.

4.5 Water conservation

In an area where water is scarce, the issue of large volume water usage needs to be addressed. The ENVIRON report notes that the combined discharges currently constitute more than 60% of the total river flow of the Kishon for substantial periods of the year.

Priority needs to be given to process changes that will allow significant increases in water recycling within the various plants which currently discharge a total of 15338 m^3/day. This particularly applies to the two largest industrial discharges; Haifa Oil Refineries and Haifa Chemicals, which discharge up to 8305 m^3/day and 3421 m^3/day, respectively.

In addition, the Haifa municipal wastewater treatment plant (WWTP) discharges up to 17,343 m^3/day. Clearly, long-term strategies for sewage treatment without the usage of such large water volumes need to be investigated.

4.6 Monitoring

The ENVIRON report concludes that combined effluents discharged to a three day capacity holding tank need to be monitored to characterise the final discharge. The mixing of many waste streams must not be allowed to mask high concentrations of all pollutants or the presence of toxic, persistent or accumulative chemicals in one or more of the individual waste streams.

Where individual effluents are combined and subsequently monitored prior to discharge, it may be more difficult to detect quality fluctuations in an individual waste stream, delaying or preventing the necessary corrective measures needed to processes or waste treatments.

Should combined effluent discharge quality fail to meet defined criteria on an ongoing basis, it is not clear who would be held responsible, a joint body or individual waste stream producers. It is also not clear from the report how such wastes that are unacceptable for marine discharge would be disposed of.

In addition to effluent monitoring, technological advances and new scientific or other data need to be reviewed on an ongoing basis to ensure that relevant updates are incorporated into processes and waste treatments where feasible. This is to ensure the greatest possible protection of the Mediterranean Sea and the wider environment.

4.7 Zero discharge

The ENVIRON report is dismissive of "zero discharge". It says that the option of zero discharge is an unrealistic goal which contradicts fundamental concepts of thermodynamics. The ENVIRON report appears to consider zero discharge as an idea that relies totally on treatment of produced wastes. This approach fails to consider eliminating initial production of certain chemicals through clean production technologies and the use of closed loop technologies (Santillo *et al.* 1999).

Zero discharge necessitates the adoption of clean production techniques both in industry and agriculture. It is essential that the change to clean production and material use should be supported by fiscal incentives and enforceable legislation.

Despite the dismissive attitude in the ENVIRON report, concepts such as zero discharge, the precautionary principle, clean production and elimination of pollution (as opposed to control) are, in fact, widely recognised in international law on marine pollution, including the Barcelona Convention for the protection of Mediterranean Sea, discussed below in section 4.8.

4.8 The BARCON Convention and its LBS Protocol

The Convention for the Protection of the Mediterranean Sea Against Pollution was adopted in Barcelona in 1976 and is hence known as the Barcelona Convention. It was amended in 1995 and retitled as the "Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean". It is a framework convention encompassing subsidiary Protocols, including the land-based sources (LBS) Protocol, which covers pollution to the Mediterranean Sea area caused by discharges such as those discussed in the ENVIRON report. The recently amended versions of the Convention and the LBS protocol are expected to enter into force soon and this discussion is based on their texts.

The LBS protocol requires that Parties undertake to eliminate to the fullest possible extent pollution to the Mediterranean Sea Area from land based sources and activities. Priority is given to substances that are toxic, persistent and liable to accumulate and which are present in Annex I of the LBS Protocol.

The protocol lists industrial sectors and hazardous substances that should be addresed. Furthermore, it states that consideration should be made of the use of clean production technologies and appropriate low-waste technologies through substitution by less polluting activities or substances, and to the saving of resources incorporating recycling, recovery and re-use.

The protocol also states that if the use of best environmental practice does not lead to environmentally acceptable results, that additional measures have to be applied and best environmental practice redefined.

Article 7 of the LBS protocol calls for "The control and progressive replacement of products, installations and industrial and other processes causing significant pollution of the marine environment"

Certain sectors of activity are specifically listed in the protocol for consideration, including;

- Fertilizer production
- Production and formulation of biocides
- Petroleum refining

Further, certain substance characteristics that should be considered are listed in the protocol, including;

- Organohalogen compounds.
- Biocides
- Polycyclic aromatic hydrocarbons (PAHs)
- Heavy metals and their compounds
- Radioactive substances
- Crude oils and hydrocarbons of petroleum origin
- Non-biodegradable detergents
- Compounds of nitrogen and phosphorus which may cause eutrophication
- Non-toxic substances that have an adverse effect on the oxygen content of the marine environment
- Non-toxic substances that may have adverse effects on the physical or chemical characteristics of sea water

The sectors of activity and effluent substance characteristics listed above have implications for one or more of the industries currently discharging to the River Kishon.

Further, the need to save resources such as water is enshrined within the definitions of Best Available Techniques and Best environmental Practice as laid out in Annex IV of the LBS Protocol, which states that consideration should be given to the saving of resources, and the incorporation of the concepts of recycling, recovery and re-use.

The OSPAR Convention for the Protection of the Marine environment of the North-East Atlantic includes octyl- and nonylphenol and their ethoxylates in the list of substances for priority action, which calls for the cessation of all releases to the marine environment by 2020 at the latest (OSPAR 2000). While OSPAR does not cover discharges to the Mediterranean Sea, the inclusion of these compounds in the OSPAR priority list demonstrates the potentially serious impacts caused by their marine discharge.

5. Conclusions

It is clear from the above analysis that the Haifa Bay pipeline scheme will not meet the pollution elimination aims of the Barcelona Convention and its LBS protocol. Whatever the improvements to the Kishon River, the Haifa Bay pipeline will only move pollution out into Haifa Bay.

The ENVIRON report predicts ecosystem impacts will result from the construction of a pipeline in to Haifa Bay. Increased contamination of the bay will also occur with toxic and persistent pollutants should the pipeline come into operation. It was estimated that water quality standards for some contaminants, including some heavy metals which are listed in the Barcelona Convention's LBS protocol, would be exceeded.

The scheme described in the ENVIRON report for regulation of discharges aims to set quantities or rates at which chemicals can be legally released into the environment. The report noted that even with suggested technological improvements, some of the industries would not be able to meet the required standards for discharges.

The levels of contamination could even exceed those predicted in the ENVIRON report. The policing of current discharges has been shown to be inadequate as data in the report indicates the regular breaching of discharge limits for inputs to the Kishon River. There is no reason to believe that the regulatory enforcement will improve to ensure adequate protection of Haifa Bay.

There is also a possibility that the treated sewage from Haifa will be discharged via the pipe, adding more nutrients and microbial contamination to the burden being imposed on the bay. Consequently, it is to be expected the combined inputs form all these sources will result in ecological impacts on Haifa Bay, including effects on fisheries. Those species which breed within the bay are likely to be most affected as the juveniles are more susceptible than adults to impacts from pollution.

A fundamental flaw in the overall approach for the improvements as suggested within the ENVIRON report is based upon the management and control of wastes, rather than upon their elimination.

At present no wastewater treatment of any significance is in place for the industries discharging to the Kishon. Discharge improvements based upon waste stream treatment, as suggested within the ENVIRON report, generally results in the formation of additional waste streams.

Proposed treatment of wastewaters to remove heavy metals by neutralization, chemical reduction and precipitation, or through absorption to standard biological treatment facility sludges, simply creates additional hazardous waste streams rather than eliminating the problem. The same applies for effluents containing radionuclides. The neutralization of effluents will reduce the impacts from high acidity (low pH), but will increase the total quantity of inorganic salts in all waste streams. This is particularly true for the wastes produced by Haifa Chemicals

The disposal of solid wastes derived from the treatment of wastewaters must take into account their hazardous toxic metal and radionuclide components and the subsequent ability of these pollutants to enter the environment, particularly through leaching. Any existing solid waste streams containing radioactive wastes need to be monitored and treated accordingly, but continuing generation of such hazardous residues cannot be sustained.

The state of the River Kishon itself is a testament to the devastating impacts that industrial effluents have had on its ecology. This should be a warning as to the extent of impacts that may also occur in Haifa Bay, should the industrial wastes be disposed of by dumping them there from an offshore outfall.

The ultimate aim of environmental policy should be the elimination of pollution. It necessitates the adoption of clean production technologies by industry and agriculture. The principle of clean production has already been endorsed by the Governing Council of UNEP and has received growing recognition at a wide range of intentional fora. For instance, the adoption of the one generation goal for the phase out of all hazardous substances by the OSPAR Convention in 1998 necessitates instigating clean production technology under a zero discharge strategy. The Barcelona Convention, as discussed above, has already embraced the concepts of pollution elimination, the precautionary principle and clean production.

The precautionary principle acknowledges that, if further environmental degradation is to be minimised and reversed, precaution and prevention must be the overriding principles of policy. It requires that the burden of proof should not be laid upon the protectors of the environment to demonstrate conclusive harm, but rather on the prospective polluter to demonstrate no likelihood of harm.

In clean production systems, products are designed so that they are necessary, reuseable, recyclable and generate only non-hazardous wastes. Obviously, therefore, clean production is not possible where hazardous materials are being used, particularly if they are also persistent. The heavy metal and radionuclides integral to the ores processed by Haifa Chemicals are both toxic and persistent. Consequently, the only way to eliminate these hazardous wastes is the elimination of fertilizer production from phosphate rock.

The Israeli Ministry of Environment must not implement the proposed marine discharge outfall to Haifa Bay. Investment should be made instead into measures to eliminate pollution via phasing out of hazardous substances and the implementation of truly clean and sustainable technologies.

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