COMMENTARY
Humanity at War: The Environmental Price

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The environmental damage left in the wake of the Gulf war testifies to the exploitation of the environment as a weapon in times of war. A scientific assessment of these damages—particularly the burning Kuwaiti oil wells—and their impact on atmospheric pollution and, consequently, human health, global warming, and climatic effects must be brought to bear on public and political opinion. To ensure the future of our planet, the protection of our human and natural environment must become a matter of international policy. International efforts, based on the recognition of this scientifically evident reality, must be mobilized to put an end to the exploitation of the environment as a weapon in times of war. A global commitment to the various practical measures that can help us achieve this aim must be made. [PSRQ 1991;1:214–220]

At this writing it has been well over a year since the start of the gulf crisis in August 1990.

While the military part remains a memory, the human, environmental, and infrastructural destruction left in the wake of the Gulf war remains as a reminder of the economic and ecological damages that we must face. Some of the oil wells were still on fire by the end of October 1991, and the unofficial media count of burning wells as of the end of July 1991 was roughly 740 to 750 [1]. Of these, some 291 [2] were brought under control, but the high-pressure, highest-risk wells had not been approached [2]. Kuwait's fully integrated petroleum facilities, covering all facets of exploration, drilling, production, refining, and marketing—both domestically and internationally—were badly damaged [3]. State-of-the-art Iraqi refineries are in shambles. Ef-

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forts to clean up the Gulf waters, into which 3 to 5 million barrels of oil have been spilled, are slow, and it will take considerable resources and money to return the Gulf to anything like its former state.[1] The environmental ruin of the Gulf bears silent witness to human and ecological fragility

The implications of the environmental ruin of the Gulf war range around the globe. In Iran, black rain was reported as early as March 1991 in Dezful in the North and the Bushei Province in the South [4]. In Nowshahr, Mazandaran Province, air pollution and the likelihood of acid rain as a result of burning Kuwaiti oil wells are serious threats [4] to some 2.5 million hectares of Iranian forest along the Gulf and the Sea of Oman. According to Iranian experts' statements, these forests comprise valuable industrial species [4]. Heavy smoke also darkened the skies of Susangerd, Bostan, Hamidieh, and Howeizeh in the southwestern province [4], blocking the sunlight for large parts of the day. Automobiles must sometimes turn on their headlights during the day, and shop lights and street lights often stay on, with an odor of burning oil filling the air. Columns of dust and thick smoke covered the sky over many cities in the Ahvaz, Khuzestan Province. Furthermore, "the frequent fall of black rain in the provinces affected by the burning oil wells has contaminated a major part of Iran's water resources and agricultural products" [4].

In April, Pakistan reported that "parts of Baluchistan are likely to receive more black rain as clouds moving into the province are laden with smoke particles from the massive oil fires raging in Kuwait" [4]. Black snow two inches thick was reported in the Himalayas [1]. At sufficient concentrations of carbon-soot, the absorption of solar radiation is at least doubled, and thaws can occur earlier and faster, with a consequently high run-off thereby threatening serious flooding. Bulgaria and Turkey have also reported black rain and smoke. Soviet scientists already have measured unprecedented levels of acid rain in regions of the Soviet Union, and similar fallout is expected in areas 2,000 km from Kuwait, as far away as China [1]. Even as far away as the U.S., studies are being conducted on data indicating higher than normal soot concentrations in the air recorded by the Mauna Loa Observatory in Hawaii and in Wyoming [5].

The temperature in Bahrain, which is some 250 miles south of Kuwait, dropped by some 10 degrees below the yearly average summertime temperatures. But certainly, the hardest hit so far has been Kuwait. According to Tony Burgess, a scientist from the Desert Laboratory of the University of Arizona at Tucson, who recently toured the oilfields:

> I have never seen devastation like this . . . Kuwait's desert before the war was very healthy, despite centuries of nomadic grazing and decades of oil development. It supported substantial greenery and an assortment of reptiles, birds and rodents. But now it is coated with oil residues that may affect its water permeability, the germination of seeds and the microbial life in the crust. Plants are dying because they cannot breathe through blackened leaves under dark skies. Then there are the tank tracks and the innumerable mines and bombs left from the war. It will begin to restore itself in a century [6].

EXTINGUISHING THE OIL WELLS

To evaluate further human and environmental damages, it was necessary to know the quantity of soot that was being emitted into the atmosphere, how high and how far it was likely to spread, and how long it would remain in the atmosphere. These factors are linked by a common element—time. The key question was how long it would take to put out the fires. There were conflicting reports that ranged from 10 more months to five years.

Red Adair, a leading U.S. oil well firefighter, stated in testimony before the U.S. Congress in June that the fires would not be controlled for years—perhaps four or five [7], whereas Kuwaiti officials stated that all the fires would be under control by March 1992 [5].

It was quite evident that a multinational effort was required in order to reduce the time needed to extinguish the fires by the end of 1991.

[1] An Associated Press report dated April 12, 1991 quoted Richard Golob, a private oil-spill expert who was keeping a "close watch" on the Gulf clean-up effort, as saying that Saudi Arabia had recently resuscitated the clean-up effort by allocating $50 million to it. . . "that pales in comparison to the $2 billion spent by Exxon Corp after the 1989 Exxon Valdez spill of more than a quarter million barrels of crude oil." The same report also quoted John Robinson of the U.S. National Oceanic and Atmospheric Administration as saying that "only 30,000 barrels of oil remain afloat in open waters, although nearly 1 million barrels is [sic] concentrated on or near Saudi Arabia's northern shoreline and is [sic] not expected to be recoverable." Though originally, the Saudis are said to have put the spill at 4 million barrels, a U.S. Environmental Protection Agency senior official and member of a U.S. government task force sent to the Gulf in April said, "I don't think we'll every really know how much oil [there] was."

ATMOSPHERIC POLLUTION

Combustion is usually not complete in high-intensity fires such as the burning of an oil well. As a result, smoke particles emitted into the atmosphere contain a substantial amount of soot, a complex mixture of unburnt organic matter consisting primarily of amorphous elemental carbon and oil material. The release of sooty smoke seriously affects the atmospheric radiation balance and gives rise to atmospheric perturbations. Other major dangers associated with the uncontrolled combustion of oil wells and refineries include the release of sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide, and hydrogen sulfides, many of which are toxic or potentially carcinogenic chemicals.

Assuming that 3 million barrels of oil are burnt per day, this amounts to the burning of 408,000 tons of crude oil, producing 10,200 tons of sulfur dioxide and 2,500 tons of nitrogen oxide, with carbon dioxide as the primary remaining product of combustion.[2] Since large amounts of sulfur and nitrogen oxides will be emitted into the atmosphere and come into contact with droplets of water, they will turn into nitric and sulfuric acid and will fall to the earth in the form of acid rain. The main effects of acid rain are soil acidification, groundwater pollution, and damage to vegetation, which could give rise to crop failure, possibly resulting in famine.

Sulfur dioxide typically affects human health by aggravating respiratory diseases, such as asthma and chronic bronchitis, irritating eyes, and possibly contributing to cardiovascular disease. Monitoring equipment has been installed in various stations in Kuwait and elsewhere to measure the concentration levels of toxic chemicals emitted [5].

Data on actual health consequences are not available; however, early reports suggest that there will be a discernible impact.

> Kuwaitis who have seen the blackened lungs of slaughtered animals and watched livestock and wildlife sicken and die can only wonder what effects the ubiquitous mist is having on humans. Some hospitals have reported a dramatic increase in respiratory cases. Doctors in Al-Ahmadi are seeing a rise in bronchitis and three times the usual numbers of asthma victims . . . [A] lung specialist at New York City's Beth Israel Medical Center says there may also be cases of oil pneumonia, a potentially fatal ailment in which oil smothers the tiny air sacs in the lungs [9]

GLOBAL WARMING

In discussing the global consequences of the oil fires in Kuwait, it has been said that the oil burning at the wellheads now could have been burned at the tailpipe. This statement is misleading. The oil that was not produced by Kuwait over the past year (around 2 million barrels per day) was compensated for through overproduction by the OPEC states. Saudi Arabia, for instance, used to produce around 5.45 million barrels per day and is now producing around 8.2 million barrels per day; the United Arab Emirates increased production by 400,000 barrels per day, Venezuela by 200,000. Overall, the OPEC production rate remained at practically the same level, around 23 million barrels per day, throughout the second half of 1990 and throughout the first six months of 1991 [10a, 10b, 10c].

Therefore, the 3 to 6 million barrels of Kuwaiti oil burning per day [11a] is over and above world production levels of 60 million barrels per day [11b]. If all the oil is consumed daily, then an additional 3 million increases the total burned by 5%, and, if the figure of 6 million barrels is used, there is an increase of 10% of the total amount burned throughout the world.

As is commonly known, the carbon dioxide produced from the burning of fossil fuels is the greatest contributor of greenhouse gases to global warming (55%), and its residence time in the atmosphere is 50 to 200 years [12].

POSSIBLE CLIMATIC EFFECTS

The predicting of typhoons and monsoons and their atmospheric behavior is not as yet an exact science; if it were, we could predict their times of arrival and their extent and give early warnings to countries and people in their path. However, the fact remains that, in the case of any large-scale atmospheric disturbance, the possibility that the disturbance could affect typhoons and monsoons (in terms of their onset, duration, and intensity) does exist. This is especially significant in the Southeast Asia region, where hundreds of millions of peoples' lives could be affected.

The first evaluation of the environmental impact of burning Kuwaiti oil wells took place on January

[2] One barrel of oil equals 136 kg. Kuwaiti oil has a high sulfur content of about 2.5%.

2, 1991, when a group of international scientists deliberated their findings at a symposium held in London [13].

Before August 2, 1990, Kuwait produced around 2 million barrels per day from 365 operating wells (of a total of 743), 343 of which were of natural flow, i.e., from their own pressure, and 22 of which were produced by artificial lift. In the Saudi/Kuwaiti neutral zone, the total number of wells was 652, 501 of which were producing around 300,000 barrels per day [14].

The assumption considered by scientists when evaluating the possible environmental impact of the burning Kuwaiti oil wells was that 3 million barrels per day could burn from 500 wells [14]. After 30 days, it was estimated that as a consequence of this burning, the amount of soot injected into the atmosphere would be 1.4 million tons [14]. One million four hundred thousand tons of smoke is certainly small in comparison with the amount of smoke it is hypothesized would be generated after a full-scale nuclear war, where 50 to 150 million tons of smoke is expected to be generated [15]. However, on a local and regional level, this amount of smoke and its environmental consequences should be given careful consideration.

The soot injection height was calculated to be between 3.5 and 5 km [16]. The reduction in sunlight caused by the soot would affect 20 million square kilometers of the earth's surface and was calculated to be at least 30%,[3] thereby causing cooling of the layers of the atmosphere and the surface of the earth. This fall in temperature would reduce precipitation, exerting a negative impact on agricultural productivity.

During the summer season—May to September—there is no rain in Kuwait. Since soot particles absorb solar radiation efficiently, the atmosphere permeated with soot would be heated as compared with the upper adjacent atmospheric layers and would then rise, carrying the soot particles to higher altitudes. The lofting velocity is calculated to be 700 m/day[4] [16]; i.e., the soot cloud could reach the upper troposphere, and possibly some amount could enter the stratosphere (35,000 feet), in 10 to 14 days.

As a result of the prevailing winds in the area of southern Iraq and Kuwait, which are mostly from the northwest with an average speed of 11 miles per hour [17], the mass of smoke and soot might be transported to regions remote from the Gulf. It could travel to the southern Gulf, Iran, Pakistan, India, Bangladesh, Southeast Asia, and possibly even to southern China. The smoke and soot would affect the monsoon circulation system, which responds to differences in annual temperature variations between continents and oceans, and consequently could influence the character and duration of the monsoon, which occurs in July and January. The Southeast Asia region accounts for most of the world's annual rice crop [18]. A loss of rainfall or a drop in temperature could gravely reduce the rice production for one growing season, thus threatening supplies for the hundreds of millions of people who rely on rice as their basic food staple.

Other more recent models [5] give different scenarios. One of these looks at the smoke after dis-

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[3] Assuming a 10% soot burning efficiency, 40,000 tons of soot is produced daily. Assuming that 33%, i.e., one-third, of soot particles lie in the 0.1 μ to 5 μ radius, and the residence time in the troposphere is two to four weeks, then the average column density over an area of 20 million square kilometers will be 0.025 g/m^2. The soot absorption optical depth is then equal to

$$\tau_{soot} = 0.23 \text{ [15]},$$

and the percent average reduction in solar flux reaching the ground is given by

$$1 - \exp(-\tau_{soot}/\sigma);$$

σ represents the solar zenith angle correction factor $= \frac{1}{3^{\%}}$ [15]. Because of the optical depth of the soot, sunlight reaching the surface of the earth below the soot will be reduced by at least 32%, thereby drastically cooling the lower layers of the atmosphere and the surface of the earth, and consequently reducing precipitation, which will have an effect on agricultural productivity.

[4] The soot particles that fall in the radius range of 10^{-1} μ to 10^{-3} μ are removed mainly by coagulation with other particles. For soot particles greater than 10 μ, they are removed mainly by sedimentation. The main removal process of soot particles in the 0.1 μ to 5 μ size range is scavenging by precipitation. Under normal conditions, most precipitation is formed in the lower part of the troposphere. Therefore, an injection of large quantities of soot particles on the order of 50% or more of its mass into the mid-troposphere increases the average lifetime of the soot particles, which is usually from five to 10 days. In the summer season, there is no precipitation in Kuwait between the months of May and September. Since soot particles absorb solar radiation efficiently, the atmosphere permeated with soot will be heated, as compared with the upper adjacent atmospheric layers, which will then rise, carrying the soot particles to higher altitudes. An estimated formula for the height attained by a soot cloud is given by

$$H(t) = (2Qt/\Delta\gamma\rho Cp)^{1/2},$$

where

H(t) is the cloud thickness as a function of time,
t is the time factor,
Q is the solar radiation flux of 120 watts per square meter,
$\Delta\gamma$ is 3.5°C per kilometer, the vertical temperature gradient deviation from the adiabatic one (−9.8 C/km), and ρCp is the enthalpy of the unit of air volume [16],

which gives lofting velocities of 0.7 km/day, thereby reaching the upper troposphere in about 10 days.

persion over the Tibetan plateau: the smoke would sink to the lower atmospheric layers, thereby slightly warming these layers and possibly enhancing the monsoons. It is reported that scientists are presently looking into the possibility of whether the smoke from oil well fires in Kuwait could have had any connection or influence on the typhoon that struck the coastal region of Bangladesh in May 1991, resulting in the deaths of over 100,000 people [5].

INITIATIVES TO PROTECT THE GLOBAL ENVIRONMENT

Establish an International Environmental Data Base

The initial studies undertaken on the environmental damages of the Gulf war clearly indicate a wide discrepancy in global perception. Particular reference is made to the studies that predicted that damage to the Kuwaiti oil fields would be negligible and the consequences of any such damage dismissible. Typical assumptions were that Kuwaiti oil fields could only produce 1.5 million barrels per day, within the ceiling established by the OPEC quota, and that the oil wells do not flow from natural pressure but need pumping [8].

Diverse assessments of the long-term environmental consequences of the Gulf war [19–22] have been contradictory and not much clarified by highly conflicting press reports.

The establishment of the proposed international environmental data base would thereby create a repository for the accumulation and dissemination of relevant—and scientifically accurate—data that can provide the key to responsible global decision making in times of crisis

Establish an Environmental Crisis Management System

The rapid supply of correct environmental data is essential in mobilizing global efforts to rectify any future environmental disaster, particularly of this scale.

One only has to review the number of contradictory views on the amount of damage caused by the oil fires to realize the extent of discrepancy, even among the reports of the teams that actually undertook field surveys of postwar Kuwait. It is surprising that, with all their reconnaissance satellite capabilities, the coalition forces did not provide the world with an accurate assessment of the damages incurred since the beginning of the oil fires [23, 24]. This failure emphasizes the need for the establishment of an independent system that can provide rapid assessments of global environmental crises and mobilize international resources to combat them, rapidly and efficiently.

It might not be necessary to establish a new institution; the existing United Nations Environment Program (UNEP) interagency framework can be built up.

The Recognition of Environmental Consequences at the Initial Stages of Decision Making in Times of Crisis

The scientific assessment of the potential environmental consequences of any given act in times of conflict should be introduced at the initial stages of any relevant decision making.

His Majesty King Hussein of Jordan tried to introduce the recognition of environmental consequences into the initial stages of decision making before the hostilities of the Gulf war began, in his address to the Second World Climate Conference held in Geneva in November 1990.

Although all international conflicts are best resolved by pacific means, humanity and nation-states have, regrettably, not arrived at this level of civilization as yet. Therefore, at least some contingency plans to deal with any environmental aftermath of disasters as rapidly as possible should be drawn up in advance for both regional and global catastrophes.

An Environmental Treaty Prohibiting the Utilization of the Environment as a Weapon in Times of War

An environmental treaty prohibiting the utilization of the environment as a weapon in times of war should be signed and ratified under the auspices of the U.N. and should be enacted in a manner similar to other related international conventions, such as those covering the use of nuclear, biological, and chemical weapons. A treaty outlawing the use of environmental weapons could, moreover, encompass the ecological threats posed by those three types of weapons.

A proposal from the government of Jordan has been directed to the U.N. Secretary General calling upon the General Assembly, in its 46th session beginning September 17, 1991, to investigate the exploitation of the environment as a weapon in

times of armed conflict and to establish a committee for that purpose (See Addendum.) This proposal has been submitted to the sixth committee of the General Assembly, the legal committee, in order for it to be considered in the context of the 1977 Geneva Protocols (Protocol I) and the U.N. Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (ENMOD). This Convention, established in 1978, proved painfully inadequate during the Gulf war. The ENMOD Convention never acquired sufficient status to be binding under international law, specifically among states that have not ratified it. A more binding and comprehensive reformulation (or modification) of the ineffective aspects of this treaty could also provide a more comprehensive and binding formula for the protection of the environment in times of war in the future.

IN A NEW WORLD ORDER: CONTROL THE DESTRUCTION OF THE ENVIRONMENT

The Gulf war will go down in history as the conflict that forced the world to face the danger of deliberately devastating the environment as an instrument of war. In the modern annals of war, before the Gulf war, only the war in Vietnam has been described in terms of ecological as well as human loss and destruction. In the recent Gulf war, the release of oil into the Gulf, the firing of the oil fields, and the strikes on civilian and industrial (as well as traditional) targets caused economic and environmental damage on a scale that casts a menacing shadow of ecological disaster on future conflicts.

Recovery from the environmental damage wrought by the war—which is of tragic proportions—may take decades. Furthermore, the environmental degradation is not limited to any single state's boundaries. A future repetition of the exploitation of the environment as a weapon in times of war could lead to ecological catastrophes of unprecedented and perhaps global dimensions. The protection of the environment must now be recognized as essential to human survival. The Gulf war has confronted us, as never before, with our need for new means of safeguarding the world's ecology, possibly through the signing and ratification of a multilateral treaty prohibiting the use of the environment as a weapon in times of war.

ADDENDUM

Request to the Secretary General of the United Nations, that the Assembly of the United Nations investigate the exploitation of the environment as a weapon in times of armed conflict and establish a committee for that purpose in accordance with the following explanatory memorandum. To be put on the agenda for the forthcoming session of the Assembly on September 17—under Rule 13.

In a world where all humanity is ecologically vulnerable, it has become evident that warfare is no longer a tenable policy option for civilized nations. It is common knowledge that the recent military conflict in the Gulf had an impact of tragic proportions on both the people of the region and the environment. Scientists have calculated that the environmental damage resultant from the confrontation will take decades to recover from. This emphasizes the urgent necessity to prevent any further exploitation of the environment as a means of indiscriminate destruction. The environment must be taken into consideration from the initial stages of conflict decision making by both politicians and military decision makers. In our approach to the next millennium, it is evident that closer cooperation between all nations is essential if we are to avoid further environmental destruction and conflict. All should realize that environmental degradation is not limited to the confines of any one nation state.

The existing 1977 United Nations Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques was revealed as painfully inadequate during the Gulf conflict. We find that the terms of the existing convention are so broad and vague as to be virtually impossible to enforce. We also find no provision for a mechanism capable of the investigation and settlement of any future disputes under the convention. Furthermore, the convention does not provide for advanced environmental scientific data to be made available to all states at the initial stages of crisis prevention.

We therefore propose that the General Assembly establish a committee to examine the above problems: the Committee to submit to the General Assembly, if possible by the 47th session in 1992, proposals for an efficient mechanism to combat the exploitation of the environment in times of armed conflict. We believe that this may lead to the drafting

of a new treaty and we trust that any such treaty would give all humanity the confidence to face a more peaceful future. Pending the finalization of any such treaty we would suggest that all nations should be invited to make unilateral decisions alongside the lines of the treaty.

In recognition of the importance of the free flow of information, we urge the Committee to consider the implementation of a United Nations Environmental Data Base as a confidence building measure and another step towards the international protection of the environment. This would further the precedent recommendations of the Independent Commission on International Humanitarian Issues on the international and institutional framework for disaster management as detailed in their report, first published in 1988, under the apt title of "Winning the Human Race." ❧

EDITOR'S NOTE

As of November 6, 1991, the Kuwaiti government reported that all oil well fires had been extinguished.

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