PENTACHLOROPHENOL IN THE MISSISSIPPI RIVER GULF OUTLET - PROBLEMS AND IMPLICATIONS

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ABSTRACT

As the transport of hazardous substances by water increases, the probability of accidental spills into the marine environment will grow accordingly. The problems associated with spills of hazardous substances are far more serious than oil spills both in terms of human health hazards and potential environmental damage. Tracking the spread of an often invisible but possibly dangerous contaminant throughout the physical and biological phases of the marine ecosystem is only one of the major difficulties encountered in this type of spill.

During a recent spill of pentachlorophenol (PCP) into a ship channel in New Orleans, Louisiana, many of the problems unique to hazardous materials were encountered and had to be addressed within strict time constraints. This paper lists the most common problems encountered at hazardous materials spills, briefly describes the PCP incident, and discusses implications of the growing marine transport of hazardous chemicals to humans and their environment.

1. INTRODUCTION

The manufacture, transport, storage, use, and disposal of hazardous materials have increased dramatically over the past twenty-five years. In the United States alone, production of synthetic organic chemicals has increased from 3.3 billion pounds in 1939 to 255 billion pounds in 1977 (1). Over 3,000 spills of hazardous materials into navigable waters are now estimated to occur each year (14), ranging in size from a few millimeters to billions of liters (2).

Unique and potentially dangerous problems are presented by spills of hazardous materials which threaten the health and welfare of both humans and the environment. Some of these problems were encountered during a recent spill of a derivative of one of the most commonly spilled hazardous materials. Over 12 tons of the phenols, pentachlorophenol (PCP), was spilled into the Mississippi River Gulf Outlet 20 miles southeast of New Orleans, Louisiana, in July of 1980. A brief synopsis of the spill incident is given, some of the typical problems of hazardous materials spills are listed, and implications of the ever-growing hazardous materials industry are considered.

2. PROBLEMS INVOLVED WITH HAZARDOUS MATERIALS SPILLS

The problems associated with hazardous materials spills are far more significant than those of oil spills both in terms of human health hazard and potential for environmental damage. In the first place, the kinds of substances spilled are so diverse and potentially dangerous, they have been divided into the following eight general United Nations Classes of compounds for the purpose of quick hazard identification (6).

- explosives
- gases
- flammable and combustible liquids
- flammable solids
- oxidizers and organic peroxides
- poisons
- radioactive materials
- corrosives

Secondly, exposure to substances from these eight classes can lead to either immediate health effects - from fires, explosions, poisoning, contamination, suffocation, chemical burns, intensive heat and extreme cold - or delayed health effects - from such causes as infectious organisms, pathogenic organisms, irritants, bioaccumulation, mutagens, carcinogens, teratogens, poisons, and corrosives. It is obvious, therefore, that the damage potential from hazardous materials to the health and welfare of humans as well as to the environment is immense.

As part of a safe and effective response to spills of hazardous materials, a number of critical questions must be asked in order to insure that all of the potential problems associated with such spills are addressed. Most of the management/scientific questions are similar to those questions formulated for systematic response to oil spills although they have been modified to fit the difficulties of hazardous materials (9,10). However, deriving quick and accurate answers to these questions during a spill response requires a highly organized response system which includes a complete pre-spill evaluation of the many diverse and dangerous problems associated with hazardous materials. Ten of the most frequently asked spill questions are listed in Table 1 and the many problems associated with addressing each question are presented in Tables 2 through 11.

Table 1

MANAGEMENT/SCIENTIFIC QUESTIONS FREQUENTLY ADDRESSED AT SPILLS OF HAZARDOUS MATERIALS

1. What was spilled?
2. How hazardous are the spilled substances?
3. What precautions should be taken to protect human health and welfare?
4. Where will the spilled substances go?
5. Can the spilled substances be contained at the spill site?
6. What containment and cleanup strategies can be used to minimize human health effects and environmental damage?
7. What are the environmental and socio-economic resources at risk from the spilled substances?
8. What are the environmental and socio-economic protection priorities?
9. What were the impacts of the spilled substances on humans and the environment?
10. What was the fate of the spilled substances?

3. THE PENTACHLOROPHENOL SPILL AND ASSOCIATED PROBLEMS

On July 22, 1980, a collision occurred between the Panamanian bulk carrier Sea Daniel and the German container ship Testbank in the Mississippi River Gulf Outlet, a ship channel approximately twenty miles southeast of New Orleans, Louisiana. As a result of the damage to the ships, four containers were lost overboard. The four containers held household goods, lube oil, scrap metal, and twelve tons of pentachlorophenol (PCP) in 50 pound paper bags. In addition, an unknown number of drums of hydrobromic acid (Hbr) were lost overboard or ruptured, spilling hydrobromic acid onto the decks of the Testbank and into the water. The containers of lube oil, household goods, and scrap metal posed no unusual problems for the cleanup crews and were subsequently removed and disposed of. Response personnel were, however, immediately confronted with a significant spill of hazardous materials with the following characteristics:

Hydrobromic Acid (3)

a. Health hazards
   - vapor
     - poisonous if inhaled
     - irritating to eyes, nose, and throat
   - liquid
     - poisonous if swallowed
     - will burn skin and eyes
     - will cause frostbite
   - inhalation causes severe irritation of nose and upper respiratory tract, lung injury. Ingestion causes burns of mouth and stomach. Contact with eyes causes severe irritation and burns. Contact with skin causes irritation and burns.

b. Water pollution
   - dangerous to aquatic life in high concentrations
   - may be dangerous if it enters water intakes
   - aquatic toxicity: 10-100 ppm/96 hr/TL_m/ (Species not specified)
   - food chain concentration potential: none

Pentachlorophenol (3,5)

a. Health hazards
   - dust
     - irritating to eyes, nose and throat
     - if inhaled, will cause coughing or difficult breathing
     - dangerous to breathe
     - corrosive to skin
   - solid
     - poisonous if swallowed
     - will burn skin and eyes
   - causes smarting of the skin and first degree burns on short exposure; may cause secondary burns on long exposure
   - dust or vapor irritates skin and mucous membranes, causing coughing and sneezing. ingestion causes loss of appetite, respiratory difficulties, anesthesia, sweating, coma. Overexposure can cause death.

b. Water pollution
   - harmful to aquatic life in very low concentrations
   - may be dangerous if it enters water intakes
   - aquatic toxicity: 5ppm/3 hr/trout/lethal/ fresh water
   - food chain concentration potential: 30-100 = "bioaccumulation factor"
   - lethal concentration = 100-300 mg/l (ppb)
   - EPA Criterion (fresh water) = 6.2 ppb/24 hr average/not to exceed 14 ppb ever
   - EPA acceptable limit in food = 2 mg/ person/day

When the PCP spill first occurred, initial attention was focused on the hydrobromic acid which was emitting a poisonous vapor cloud and mixing with the waters of the Mississippi River Gulf Outlet, causing immediate problems for divers, other response personnel, and nearby townspeople. Fortunately, only small amounts were spilled and it was cleaned up and moved off the spill site within a matter of days without major mishap. However, the pentachlorophenol presented a longer-term problem. The PCP, in granular form, and resembling coarse sand, disappeared into the bottom muds of the ship channel where visibility is close to zero.

PCP is a biocide used as an insecticide, fungicide, herbicide, algicide, disinfectant, and in antifouling paints, but marketed primarily as a wood preservative (12). Health effects from the PCP itself range from minor skin and lung irritation to death. As a technical grade chemical, the product contained only 88% to 92% pentachlorophenol. The remainder of the product was comprised of an unknown mixture of impurities (8). Through high resolution gas chromatography (GC) and high resolution gas chromatography-mass spectrometry (GC-MS) analyses of the original cargo, it was revealed that the PCP

was composed of three major compounds (pentachlorophenol, tetrachlorophenol, trichlorophenol), ten minor chlorinated organic chemicals (pentrachlorobenzene, hexachlorobenzene, dioctyl phthalate, hexachlorodiphenyl ether, heptachlorodiphenyl ether, octachlorodiphenyl ether, hexachlorodibenzofuran, dexachlorodibenzo-p-dioxin, heptachlorodibenzo-p-dioxin, octachlorodibenzo-p-dioxin), and trace amounts of two hundred chlorocarbons (7).

Although the dioxins were present in only small amounts, their extraordinarily high toxicity and high bioaccumulation tendencies make them potentially very dangerous to both humans and the environment (4,11). Therefore, besides the problems created by the spill of hydrobromic acid and pentachlorophenol into the Mississippi River Gulf Outlet, there were many additional health and environmental difficulties caused by the discovery of dioxins in the spilled cargo.

For the next month, the U.S. Coast Guard and response groups from other federal, state, and private sources continued the very difficult task of trying to clean the bottom of the ship channel and surrounding areas of a pollutant which was now essentially invisible. The effort cost nearly three million dollars, the evacuation of over 75 people, the closure of 400 square miles of Louisiana waterways to fishing, considerable anxiety over the impact to the health of local residents and response personnel, and public loss of confidence in the local fishery (4). Fortunately, there were neither any reports of significant illness or injury as a result of the incident, or long-term contamination problems in any of the fish or shellfish from the region.

The problems resulting from spills such as the PCP incident of hazardous materials are, however, complex and dangerous. These problems must be anticipated before incidents occur and should be included in the development of the response decision-making process. Some of the most common problems associated with hazardous materials spills are listed in Tables 2 through 11. For the purposes of pre-spill planning, they have been divided into groups and placed under the most appropriate spill question.

Table 2

Potential Problems Associated with Answering Management/Scientific Question: (1) WHAT WAS SPILLED?

- unwillingness/inability of spiller to disclose complete identity of spilled product
- placarding/labeling - too general
- incorrect, incomplete, missing or destroyed cargo manifest
- missspelling of trade, common, or technical name of product
- presence of potentially hazardous impurities in product spilled
- potential risk to field, laboratory, and response personnel when working with unknown substances

Table 3

Potential Problems Associated with Answering Management/Scientific Question: (2) HOW HAZARDOUS ARE THE SPILLED SUBSTANCES?

- possibility for following hazardous materials to be spilled singly or in combinations:
  - explosives
  - gases
  - flammable and combustible liquids
  - flammable solids
  - oxidizers and organic peroxides
  - poisons
  - radioactive materials
  - corrosives
- potential for the following health effects (singly or in combination) from:

Immediate	delayed
. fires	. pathogenic organisms
. explosions	. corrosives
. poisoning	. irritants
. contamination	. bioaccumulation
. suffocation	. mutagens
. chemical burns	. carcinogens
. intense heat	. teratogens
. extreme cold	. poisons

- available information on hazards of spilled products - sparse or incorrect.
- impurities - more toxic than product
- aquatic and marine pollution information - not available or incomplete for many substances
- many highly dangerous substances - odorless, colorless, tasteless
- dangerous reactivity with water, air, light, sediment
- incompatibility of spilled substances with dangerous or unknown reactions among spilled substances
- synergystic effects of spilled substances on humans and environment
- criteria for federal and state "acceptable" levels of conteminant can be based on insufficient data.

Table 4

Potential Problems Associated with Answering Management/Scientific Question: (3) WHAT PRECAUTIONS SHOULD BE TAKEN TO PROTECT HUMAN HEALTH AND WELFARE?

- personnel risks at spills of unknown substances
- unwillingness of some response personnel to adhere to established safety guidelines
- response personnel unfamiliar or untrained in use of personal protection equipment
- proper protective equipment and clothing may not be available
- lack of pre-spill planning by all or part of response community
- confusion about chain of command among disaster response groups
- evacuation may be physically impossible or impractical
- evaluation of protective measures difficult in "mystery" spills
- response efforts hampered by severe or unusual weather
- unknown atmospheric dispersion rates for many hazardous substances
- traffic control often difficult
- unnecessary anxiety and panic caused by irrespondible press
- extreme public or political pressure to "do something" before response personnel safely prepared

Table 5

Potential Problems Associated with Answering Management/Scientific Question: (4) WHERE WILL THE SPILLED SUBSTANCES GO?

- unknown or unpredictable physical/chemical behavior of one or more of the spilled substances or reaction products in water, sediment, and air
- environmental pathways and processes involved in uptake and transfer of contaminants poorly understood in many cases
- difficult to track the spread of some substances due to lack of color or odor, sinking, mixing with sediment, water, and air
- occurrence of spills into complicated water systems such as estuaries, channels, canals, marshes, lagoons, bayous, rivers, etc.
- data on weather patterns and/or water circulation (including tidal and estuarine flow) insufficient for prediction of accurate spill trajectories
- physical and chemical characteristics of water in area - not immediately available (e.g., pH, salinity, temperatures, oxygen content)
- stratification and mixing rates and patterns not always known for local waters
- alteration of normal water and atmospheric flow patterns due unusual or severe weather conditions
- rapid atmospheric dispersion of product

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Table 6

Potential Problems Associated with Answering Management/Scientific Question: (5) CAN THE SPILLED SUBSTANCES BE CONTAINED AT SPILL SITE?

- state of the art for hazardous materials containment and cleanup not sufficient for safe and easy handling of some commonly spilled substances
- danger of explosion, fire, or other immediate hazard
- insufficient containment equipment, personnel, and materials
- public and political pressure to do so before response personnel ready
- rapid loss of product to surrounding waters, sediment, or air
- limited visibility in vicinity of spill site
- inclement weather
- strong winds and water currents

Table 7

Potential Problems Associated with Answering Management/Scientific Question: (6) WHAT CONTAINMENT AND CLEANUP STRATEGIES CAN BE USED TO MINIMIZE HUMAN HEALTH EFFECTS AND ENVIRONMENTAL DAMAGE?

- state of the art cleanup and containment techniques and equipment not sufficient for safe and easy handling of some commonly spilled substances
- federal and state response agencies still learning about hazardous materials - fate, effects, cleanup strategies, etc.
- cleanup techniques sometimes more damaging to environment than spilled substance

- presence of large numbers of personnel, equipment, and activities sometimes damaging to environment
- local resource information not always available for area
- local weather may prevent use of most effective cleanup techniques
- locating acceptable and safe disposal sites for cleanup materials and spilled product often difficult

Table 8

Potential Problems Associated with Answering Management/Scientific Question: (7) WHAT ARE THE RESOURCES AT RISK FROM THE SPILLED SUBSTANCES?

- fate and effects of some spilled substances throughout the environment unknown or poorly understood
- data on socioeconomic and environmental resources of area may often by unavailable or limited, especially early in the spill
- may be difficult to predict accurate trajectories for the spilled substances
- may not be possible to confirm existing published resource data for area
- local sensitivities and priorities may be unknown or poorly understood

Table 9

Potential Problems Associated with Answering Management/Scientific Question: (8) WHAT ARE THE ENVIRONMENTAL AND SOCIOECONOMIC PROTECTION PRIORITIES?

- data on socioeconomic and environmental resources of area often unavailable
- fate and effects of spilled substances often unknown or not understood
- habitats or organisms mandated by law to be protected sometimes overlooked
- political and public pressure occasionally force protection of inappropriate resources at expense of others
- local input and data on resources sometimes overlooked or ignored
- local priorities sometimes overlooked or ignored

Table 10

Potential Problems Associated with Answering Management/Scientific Question: (9) WHAT ARE THE IMPACTS OF THE SPILLED SUBSTANCES ON HUMANS AND THE ENVIRONMENT?

Human Health and Welfare

- lack of prespill medical data on effected individuals and populations
- influences of normal background contaminants on impacted individuals and populations
- lack of epidemiological information on impacted subjects
- legal difficulties in attempting to sample civilians
- statistical and logistics problems in sampling large numbers of individuals from varied socioeconomic groups
- unnecessary public anxiety and worry caused by sensational press coverage and irresponsible statements by responding officials
- documentation of contamination of impacted ground water surface water, soil, air, well water

Environmental

- lack of prespill faunal and floral surveys of impacted environments
- lack of data on background levels of ambient contaminants
- confusion of impact with natural variability of population
- difficulty in finding dead organisms for body counts - especially, in remote areas and with small sized organisms
- designing damage assessment program acceptable to all parties
- determining what quantity of contaminant caused impact
- preventing press from causing panic in consumer markets of threatened resources
- formulation and acceptance of sampling plan

Table 11

Potential Problems Associated with Answering Management/Scientific Question: (10) WHAT WAS THE FATE OF THE SPILLED SUBSTANCES?

- unknown physical/chemical behavior of spilled products in environment
- inability to follow spread of spilled substances throughout the environment by direct observation
- lack of information on conversion of spilled substances to breakdown products, reaction products, metabolic products in the environment
- ignorance of pathways, receptors, processes involved in an interaction between the substances and the living and non-living environment
- difficulties in quantifying amounts of spilled substance:
  - recovered in cleanup operation
  - evaporated
  - carried away by air or water currents
  - converted to other products
  - absorbed
  - adsorbed
  - taken up by living organisms
  - dissolved
  - dissipated throughout the environment

4. IMPLICATIONS OF HAZARDOUS MATERIALS SPILLS

The human appetite for advancement and convenience has created unlimited opportunities for industry and the economy, but infinite problems for both human health and welfare and the environment. The present products and by-

products of modern technology increasingly have the capability to cause an appalling variety of injuries, contamination, diseases, or deaths. Furthermore, it is no longer possible to avoid contamination during normal contact with air, water, food, ground, and materials. It is not necessary to belabor the environmental message and implications of global pollution but it should be stated that the role of hazardous materials in the pollution issue is, indeed, significant.

While spills may be only one source of chemical pollution, the spills factor is easier to document and control than many other types of pollution. It is unfortunate that the manufacture, transportation and use of hazardous materials is increasing so rapidly and that most marine spills of oil and hazardous substances occur in rivers, ports, and harbors, and, therefore, near major metropolitan areas (13), but it is encouraging that it may still be possible to have a positive impact on the problem. As the incidence of hazardous materials dump site problems, spills, and contamination grows, public awareness has also increased considerable. Superfund legislation has been passed by the Senate. Federal, state and private response groups are improving their abilities to respond safely and effectively and better cleanup and containment techniques and materials are being developed rapidly. Disposal sites are being selected with more care and planning, while the reconnaissance and cleanup of old sites continues. Ultimately, perhaps, more stress will be placed on prevention of the accidents and situations which cause spills. Through these influences, it is hoped that at least some of the hazardous materials spill problems can be eliminated or ameliorated.

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