

Pulp and Paper Mill Effluents Potentially Increase Cancer Rate

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Abstract

Objective: Epidemiological studies have provided preliminary data illustrating elevated cancer rates in the vicinity of a paper production facility. Georgetown, SC is a site for International Paper where documentation of cancer is extremely high. This research was conducted to support the hypothesis that pulp and paper mill effluents cause cancer. **Materials and Methods:** Data were analyzed from multiple articles studying cancer incidence and mortality as well as interviews, court cases, and EPA data files. **Results:** There is enough evidence to conclude that International Paper is disposing carcinogenic chemicals into the local Sampit River.

Conclusions: From the research it is possible to conclude that the chemicals released are hazardous to humans. The chemicals need to be further analyzed to determine which chemicals are increasing cancer in the vicinity of a mill.

Pulp and Paper Mill Effluents Potentially Increase Cancer Rate

Introduction

Known for their pungent odor and billowing smoke, paper mills operate throughout the world and can pose a serious hazard to the health of the environment and the people exposed to them. Georgetown, South Carolina, a site of International Paper located on the Sampit River, has been in operation since 1937 and produces 632,000 tons of product each year (SCIWAY, 2012). As one of the largest private employers of Georgetown County, International Paper significantly affects the lives of the local population. The National Cancer Institute estimates that during 2007-2011, Georgetown County had an annual incidence rate of 489.3 per 100,000 people, adjusted for age (State Cancer Profiles, 2014). This is the third highest cancer rate of South Carolina counties. It is believed that health issues documented from the paper mill employees and citizens of Georgetown could be attributed to the local International Paper facility. Lawsuits were filed against the mill to gain compensation for community members' poor health. However, two years later the court cases were dismissed due to a lack of scientific research regarding the water pollution and health concerns claiming "[...] they were too vague and failed to support claims of personal injury or property damage" (Chiem, 2012).

The processes of breaking down plant fiber into a thick board material and converting it into paper release harmful effluents into the environment, causing adverse effects. The waste contains lignins, inorganic material, transition metals, and other harmful agents. Once the production process has been completed, the waste is discarded into nearby rivers and lakes; contaminating the air through evaporation, the soil through runoff, and the water through direct

disposal. The Environmental Protection Agency estimates that in 2006, 200 million pounds of hazardous wastes were produced by paper mills in the United States (USA Today, 2009).

International Paper is responsible for the release of at least two known carcinogens into the local environment. One of these chemicals, acetaldehyde, is used in the manufacture of acetic acid and is thought to disrupt cellular metabolic processes. According to EPA research, International Paper released 16,301 pounds of acetaldehyde into the Sampit River and 82,710 pounds into the air in 2013 (United States Environmental Protection Agency, 2014). Another harmful chemical used in paper production is formaldehyde, classified by the EPA as “a probable human carcinogen in cases of prolonged exposure” (USA Today, 2009). EPA research notes that in 2013, the Georgetown facility discharged 26,071 pounds of formaldehyde into the river and 16,381 pounds into the air (United States Environmental Protection Agency, 2014).

Studies have been conducted in areas housing industrial facilities including pulp and paper mills in Sweden, Spain and Poland, and a dye facility in New Jersey known as Toms River Chemical Company. These studies were conducted to show the harmful effects pulp and paper mill effluents have on health, specifically cancer.

Discussion

Techniques used to study cancer risk in and around mills are limited. Some researchers use publicly available data to determine a standardized mortality ratio or standardized incidence ratio for a chosen area. This gives the occurrence of the cancer incidence or mortality in contrast to the expected value of the general public. These methods can make results difficult to interpret because confounding variables may not be taken into consideration. A more in-depth method is to survey the group being studied, which can provide information such as exposure duration or show the presence of confounding variables. This method is difficult to accomplish with a large

number in the cohort, such as a study of a large population inhabiting a city near the industrial facility.

Health concerns directly related to mill pollution have risen as cancer rates have increased in areas surrounding the mills. Those most susceptible to the toxins are mill employees. Research performed in Sweden focused on cancer incidence among employees of sixteen pulp and paper mills. Employee files provided the necessary information including: name, date of birth, and duration of employment (minimum of one year). In total, 20,405 Swedish mill employees met the criteria and were included in the cohort. Records from the Swedish Cancer Registry were used in comparison to the data to determine if mill employees were diagnosed with cancer more often than the general population.

Preliminary information was categorized by type of mill in which the employee worked: sulphate or sulphite, and wood preparation or paper production. The department title was used as the pollutant exposure level; the level increased as employees were closer to the chemicals. The data collected were categorized based on gender, age group, and one-year calendar periods. In order to develop an expected value for each category, the general Swedish population was utilized for reference. The data were compared separately from the inhabitants of three main Swedish cities to reduce analytical error due to traffic and other pollution sources not as prevalent in the mills' rural locations. Employees not at risk of chemical exposure, such as those working in administration, were removed from the study to further reduce analytical error.

Of the 20,405 mill employees included in the study, 2,305 were diagnosed with cancer in the years the study was conducted. In comparison to the Swedish male population, mill employees exhibited an increase in rates of testicular cancer. Additionally, female employees

showed a slight increase in incidence of skin tumors and melanoma. Although the analyzed data showed minor increases of cancer incidence in mill employees, the original hypothesis could not be supported. There were insufficient results to conclude that mill effluents caused cancer in pulp and paper mill employees.

It is believed that weaknesses in this study were responsible for the lack of conclusive evidence, specifically that there was no interaction between the researchers and the workers of the mills. There was a lack of information regarding the physical work executed at the mills because all data was acquired through the Swedish Cancer Registry. It is believed that the hypothesis would have been better supported if the type of work performed by the employees and a list of protective gear worn had been analyzed.

However another study was able to make a connection between pollutants and increased cancer among employees. A 2004 risk assessment in Poland was performed through a cohort of 8,568 male mill employees to gauge the relative risk in lung cancer mortality as a result of mill effluents. Included in the cohort were birth date, duration of employment, department worked, and cause of death if deceased. The mortalities of the entire male population of Poland were used as the control group. The preliminary data were categorized based on the position held at the mill and number of years exposed to the carcinogens. This information was then compared to the number of lung cancer mortalities among the employees. A risk assessment model was formulated in order to assess the data in a numerical format.

The data were analyzed using both a Poisson regression and Cox proportional hazards model to assess the risk of lung cancer mortality. Both models are appropriate in measuring risk because the data were independent and described rates. The assessments indicated an increase in lung cancer risk related to longer duration of employment and exposure to mill effluents.

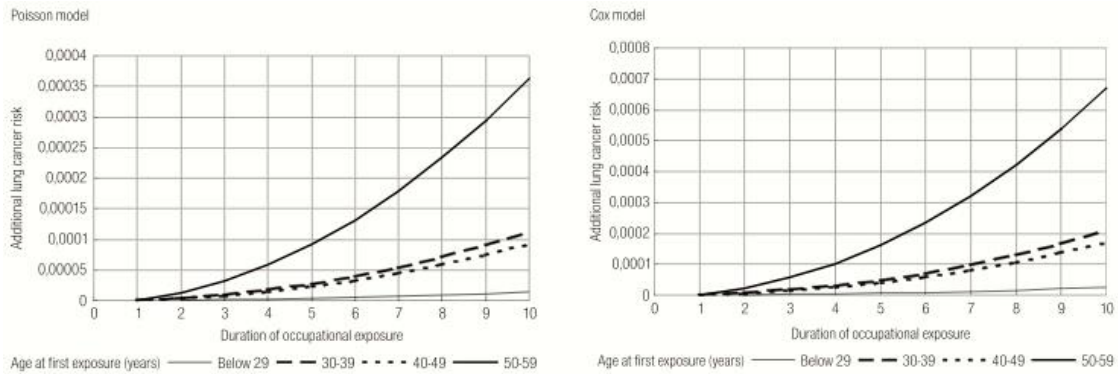


Fig. 1. Relationships between duration of employment in the pulp and paper mill production departments and additional cancer risk among male workers, depending on age at first exposure. The use of the Poisson and Cox models was an intermediate stage of risk assessment.

(Szymczak & Szadkowska-Stancyk, 2004).

The figure illustrates that the employees younger than twenty-nine years when they obtained their first chemical exposure experienced a lower risk of developing lung cancer. Employees who were between the ages of fifty and fifty-nine when first exposed experienced a higher risk. It was calculated that those employed for 1-5 and 5-10 years were at risk of lung cancer mortality 1.41 and 1.68 times higher than the control population respectively.

In an attempt to reduce error in data analysis, confounding variables were eliminated. As studies show, smoking causes a number of ill health effects especially lung cancer. The Centers for Disease Control and Prevention reports that ninety percent of lung cancer mortality is due to smoking (CDC, 2004). It was assumed that the amount of smokers employed at the mill and the amount of smokers in the general Poland population would proportionally be similar, so that information was not included in the analysis. The results of this study provided sufficient evidence to conclude that pulp and paper mill effluents increase the relative risk of mill employees developing lung cancer.

While employees have higher exposure to paper mill wastes, the inhabitants of areas surrounding the mills are also exposed to these effluents. Because elevated risk in mill workers had already been supported by prior studies, researchers in Spain hypothesized that inhabitants in

towns around mills would share this increased risk. A 2008 study conducted in Spain focused on mortality of people in nearby towns. After defining the exposed group as towns located within two kilometers of the industrial facility, the researchers formulated standardized mortality ratios from lung cancer deaths. A control group was defined as towns located farther than two kilometers from a paper mill. Publicly available data from thirteen towns were used in the study, and socioeconomic factors were controlled with limited success.

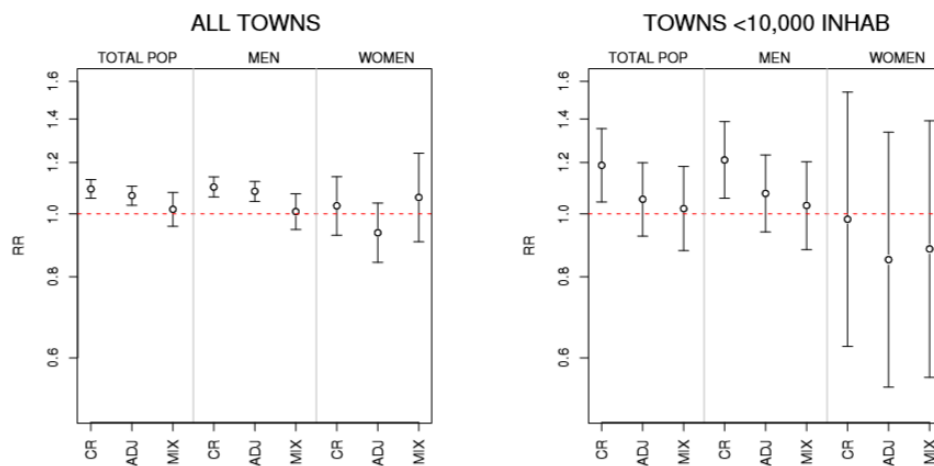


Figure 1
Relative risks (RR) and 95% confidence intervals for towns situated less than 2 km from paper and board industries, estimated using different models. CR = crude RRs, ADJ = adjusted RRs (population size, illiteracy, unemployment, farming, income and persons per dwelling), MIX = RRs adjusted for the above variables and including province as a random effects term. INHAB = inhabitants.

(Monge-Corella, et al., 2008)

Although two towns did show increasing risk with decreasing distance from the mill, no direct link could be determined. This is due in part to confounding variables that make the results difficult to interpret. The scientists could not conclude if additional sources of carcinogens, such as smoking and other industrial pollution, were the cause of the cancer mortality. In addition, effluent distribution through air and water can differ from geographic distance; this can alter the accuracy of the subject's exposure. Furthermore, incomplete data

from the public database used in the research further limited the study. While no direct link was found, the study is a good starting point for future research.

Another case of industrial pollution harming populations is chronicled in Dan Fagin's 2013 narrative, *Toms River: A Story of Science and Salvation*. The chronicle recounts the story of the people of Toms River, New Jersey and their fight against industrial pollution and childhood cancer. Chemical manufacturer Ciba-Geigy opened a dye-making facility in Toms River in 1952. The company knew that the facility would cause major pollution in Toms River, but assumed that because it was in an isolated area surrounded by trees and land, it would not have a direct effect on the citizens. The New Jersey Department of Health "[...] asserted that 'according to experience' from other dye factories, the Toms River plant's wastewater discharges would be 'clear and transparent,' 'have no odor,' and 'be free of substances harmful to fish, animal or wildlife'" (Fagin, 2013). Ciba-Geigy knew that this information was incorrect due to prior experience with another facility.

Harmful chemicals are used in the process of making dyes including: nitrobenzene, naphthalene, sulfuric acids, lye, ammonia, and arsenic acid. Arsenic acid is a transparent chemical that is detrimental to humans and the environment and must be kept out of the wastewater at all times. In Toms River, more than six thousand pounds of the carcinogen-laced wastewater were dumped into the nearest waterway each day. The groundwater was contaminated after chemicals seeped through the porous soil, and the water supply was completely polluted in just two years. Additionally, Ciba-Geigy had stored 35,000 drums of waste in an unlined landfill further contaminating the area. The waste included trichloroethylene, tetrachloroethylene, benzene, and chloroform, all of which are hazardous to humans.

In Toms River, the incidence rates in children were significantly higher than expected for every type of cancer. There were seven percent more cases than anticipated in Ocean County, thirty-one percent more in the township, and forty-nine percent more in the core area defined as Toms River.

	Age	Observed	Expected	Incidence Ratio
COUNTY:				
All Cancers	0-19	230	215.5	1.07
Brain/CNS	0-19	54	38.8	1.39
	0-4	21	12.0	1.75
Leukemia	0-19	60	53.4	1.12
TOWNSHIP:				
All Cancers	0-19	56	42.7	1.31
Brain/CNS	0-19	11	7.6	1.45
	0-4	5	1.9	2.64
Leukemia	0-19	16	10.2	1.58
TOMS RIVER CORE ZONE:				
All Cancers	0-19	14	9.4	1.49
Brain/CNS	0-19	5	1.6	3.05
	0-4	3	0.4	7.14
Leukemia	0-19	4	2.2	1.80

(Fagin, 2013)

The results of this study show overwhelming evidence that cancer was higher in areas around the industrial facility. As more research was performed to ensure that the cancer rates were caused by the dye manufacturer, it was found that the water in thirteen schools was slightly radioactive. Researchers predicted that many of the 90,000 people of Toms River were drinking contaminated water that the government considered unacceptably radioactive. This water was traced back to Reich Farms where Ciba-Geigy had been storing the drums of waste in the

landfill. Due to their negligence, “[...] the Toms River childhood cancer cluster was a man-made catastrophe, and a preventable one” (Fagin, 2013).

Future Research

Eva Andersson, the lead researcher of the study investigating cancer incidence among Swedish paper mill employees, affirmed in an interview that “it’s not possible [to confirm mills cause cancer in employees] regarding an individual worker [...]. We could only say on a group level that it seems that the workers had an increased risk [of developing cancer] compared to other people in the country” (personal communication, November 13, 2014). Although evidence supports that cancer incidence and mortality is elevated in the vicinity of a mill, further research is required to identify the paper mill as the source of the cancer.

Andersson asserts that further research is crucial, “We plan to update this study in coming years” (personal communication, November 13, 2014). While chemicals used in the dye plant differ from those in paper production, there is a connection in both increasing cancer incidence and mortality. It is possible that other production industries could also be connected. The researchers of the Swedish cohort plan to incorporate that idea by investigating soft tissue paper mills in the future (personal communication, November 13, 2014).

Conclusions

While some studies did not have conclusive evidence to support the claim, others were successful. The results from the successful studies show an increase in cancer rate and a heightened risk of mortality in areas surrounding pulp and paper mills. This information is necessary in providing epidemiologists in Georgetown, SC with the proper research ideas to pursue International Paper’s hazardous disposal of chemical waste.

References

- Andersson, E., Westberg, H., Bryngelsson, I., Magnuson, A., & Persson, B. (2013). Cancer incidence among Swedish pulp and paper mill workers: A cohort study of sulphate and sulphite mills. *International Archives of Occupational and Environmental Health*, 86(5), 529-540. Retrieved September 1, 2014.
- Chiem, L. (2012, October 24). International Paper Pollution Suits Too Vague, Judge Says. Retrieved November 16, 2014, from <http://www.law360.com/articles/389021/international-paper-pollution-suits-too-vague-judge-says>
- Fagin, D. (2013). *Tom's River: A Story of Science and Salvation*. New York City: Bantam Books.
- Highlights: Smoking Among Adults in the United States: Cancer. (2004, May 27). Retrieved November 12, 2014, from http://www.cdc.gov/tobacco/data_statistics/sgr/2004/highlights/cancer/index.htm
- International Paper Co Georgetown Mill. (2009). Retrieved November 17, 2014, from USA Today
- International Paper Mill. (2012). *SCIWAY: South Carolina's Information Highway*. Retrieved November 10, 2014.
- Monge-Corella, S., García-Pérez, J., Aragonés, N., Pollán, M., Pérez-Gómez, B., & López-Abente, G. (2008). Lung cancer mortality in towns near paper, pulp and board industries in Spain: A point source pollution study. *BMC Public Health*, 8(288), 1-11. Retrieved September, 2014.

Szymczak, W., & Szadkowska-Stanczyk, I. (2004). Quantitative assessment of lung cancer risk in men employed in the pulp and paper industry in Poland. *International Journal of Occupational Medicine & Environmental Health*, 17(2), 263-272. Retrieved September, 2014.

State Cancer Profiles. (2014). In *National Cancer Institute*. Retrieved November 13, 2014.

Transforming Paper Mill Pollution into Commercial Resource. (2013, September 3).

Retrieved November 12, 2014, from

<http://www.epa.gov/sciencematters/june2011/papermill.htm>

United States Environmental Protection Agency. (2014). *Toxic releases for reporting year 2013* [Data file]. Retrieved from

http://oaspub.epa.gov/enviro/multisys2_v2.get_list?facility_uin=110000353466

Annotated Bibliography

Andersson, E., Westberg, H., Bryngelsson, I., Magnuson, A., & Persson, B. (2013).

Cancer incidence among Swedish pulp and paper mill workers: A cohort study of sulphate and sulphite mills. *International Archives of Occupational and Environmental Health*, 86(5), 529-540. Retrieved September 1, 2014.

Documentation of cancer among employees of Swedish pulp and paper mills were higher than average. A cohort was performed analyzing the department worked and duration of employment. Data were compared to the general public to support an increase in rates per department and gender. The results show increased rates in certain types of cancers but the study could not conclude that mills cause cancer as a whole.

Monge-Corella, S., García-Pérez, J., Aragonés, N., Pollán, M., Pérez-Gómez, B., &

López-Abente, G. (2008). Lung cancer mortality in towns near paper, pulp and board industries in Spain: A point source pollution study. *BMC Public Health*, 8(288), 1-11. Retrieved September, 2014.

Lung cancer is the leading cause of cancer-related death in men in Spain. An ecological study compared the number of observed to expected lung cancer mortality in thirteen Spanish towns. Mortality increased in two towns with decreasing distance from the mill. No direct link could be established between cancer and paper mills due to limitations of the study.

Szymczak, W., & Szadkowska-Stanczyk, I. (2004). Quantitative assessment of lung cancer risk in men employed in the pulp and paper industry in Poland. *International Journal of Occupational Medicine & Environmental Health*, 17(2), 263-272. Retrieved September, 2014.

Lung cancer mortality rates are significantly high in men employed in pulp and paper mills in Poland. A cohort of 8,568 male mill employees was performed to assess the relative risk of lung cancer mortality. The department worked and duration of employment were analyzed into an exposure level value. The results concluded that a numerically larger exposure level lead to an increase in lung cancer mortality.

Appendix

Eva Andersson was contacted via email on November 8, 2014. (eva.andersson@amm.gu.se)

1. Where in Sweden were the mills located?

A map was provided as a reply

2. Did you conduct any one-on-one interviews with employees?

“It is more than 20000 workers, so no. Some of them have answered questionnaires.”

3. What types of chemicals did you find were causing workers to develop cancer?

“For some cancers there are good hypothesis such as asbestos. But for others we don’t know. I think we discuss this in the paper. You can also look in the following paper where there is more about exposures in the pulp mills: Andersson E, Persson B, Bryngelsson IL, Magnuson A, Westberg H. Cancer mortality in a Swedish cohort of pulp and paper mill workers. 2009 DOI 10.1007/s00420-009-0446-1. Int Arch Occup Environ Health 2010;83:123-32.”

“If you want I can send my dissertation which also deals with cancer in pulp industry, if I get your postal address.”

“But there could also be other exposures such as shift work that could be risk factors for cancer.”

4. Do you have any plans for further research?

“We plan to update this study in coming years and we also are doing studies on soft tissue paper mills.”

5. Do you think it is possible to confirm that mills cause cancer in workers?

“For some exposures as asbestos, yes, but otherwise it’s not possible regarding an individual worker to know how he/she got their cancer. We could only say on a group level that it seems that the workers had an increased risk compared to other people in the country.”

Tom Fagin was contacted via email on November 15, 2014. (dan.fagin@nyu.edu)

The author replied that he would not be unable to answer the scientific questions that were going to be asked.

Wieslaw Szymczak was contacted via email on November 12, 2014. (wieszym@uni.lodz.pl)

The author replied that he did not have time to locate the original study or answer questions.