Environmental Protection: How Much Risk Reduction is Humankind Willing to Undertake? A Study about Nuclear Power Plants

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ABSTRACT

Despite the cost-efficiency of nuclear power the health and environmental implications are not as well known. Disasters such as that which occurred in Chernobyl in 1986 have seen an increase in the development of thyroid cancer in the areas in the immediate vicinity. Other studies have found that just living near a nuclear power plant does not put a person at an increased risk of malignant lymphoma or childhood leukemia. Studies of the environment have shown that nuclear power plants have little effect on the land or air, but have significant negative impacts on the aquatic environments. New safety measures, including situation specific emergency response systems, can be put into place to further reduce the risk of nuclear power plant disasters.

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Introduction

The current drive for new sources of energy in the power industry has been driven in part, by the growing demand for electricity worldwide. One viable option to using oil related energy is the use of nuclear power. The use of nuclear power has raised many safety questions, as well as possible subsequent health issues and environmental risks. The possible implications of living near a nuclear power plant and the long-term effects of a nuclear power disaster, has yet to reach a consensus (Wang, Lee, Zou, Fan, & Yaung, 2010). The lack of consensus around two questions is the basis for this paper: Do we have nuclear power under control? How much risk reduction is humankind willing to undertake?

Background

Nuclear power plant expansion in the United States has been driven by the relatively comparable cost of nuclear power to coal or natural gas and the reduced reliance on other countries for energy. In addition, nuclear power plants have been found to emit relatively few greenhouse gases in comparison to other forms of energy sources, such as coal (Ferguson, 2007). However, for nuclear power to have a substantial effect on reversing the damage on the environment and to combat human-induced climate change, the amount of new nuclear power plants would have to expand at a rapid rate, thereby resulting in lack of adequate materials, and personnel to operate and run the plants safely (Ferguson, 2007).

Other concerns of nuclear power plants stem from the use of uranium in less developed countries. Attacks on nuclear power plants could have detrimental effects and allow individuals to use the uranium for purposes of terrorism (Ferguson, 2007). In the United States the focus is on reducing the need for energy from unstable regions and on increasing energy security through having a constant and predictable source. Despite concerns over nuclear power, the subject has moved to the forefront of possible new solutions to the energy crisis that the world faces (Ferguson, 2007).

Health Implications

One of the most widely studied negative health effects of using nuclear power is the risk of cancer. Currently, a definitive link between nuclear power plant vicinity and cancer has not been found, and remains a disputed issue among researchers. Nuclear power plants are located in many different countries, and accordingly, health studies have been conducted in a variety of locations. In Germany, it has been suggested that living within a five-kilometer radius of a nuclear power plant may increase the risk of childhood leukemia (Kaatsch, Spix, Jung, & Blettner, 2008). This finding has not yet been substantiated by other research, and in fact, is unable to show a direct causal link between nuclear power plant location and the occurrence of leukemia (Lane, Reinhardt, & Thompson, 2010). Other factors that

could contribute to the increase in child leukemia offer a more plausible reason for the Kaatsch et al. (2008) findings, as the exposure to radiation was considered minimal by current standards (Zolzer, 2010). The health field has yet to agree on what other factors may have caused the increase in childhood leukemia occurrence. A better understanding of the possible factors that may have contributed to the increased incidence in Germany is needed (Nussbaum, 2009). An unknown factor causing cases of leukemia is insufficient justification for power plants to be considered a potential risk factor for cancer. Instead, these discrepancies highlight the need for better radiation risk studies (Nussbaum, 2009). At this time the overall conclusion drawn is that living near a nuclear power plant does not increase the risk of leukemia incidence in children under 5 years old (Spycher et al., 2011).

Research also has focused on the possibility that proximity to nuclear power plants causes an increase in cancer incidence in adults (Yoshimoto et al., 2004). One potential type of cancer that has been studied is malignant lymphoma in adults. Studies have not shown an increase in incidence of this type of cancer related to proximity of a nuclear power plant based on minimal radiation exposure levels (Yoshimoto, et al., 2004). Currently, the only definitive cancer that has been causally-linked to nuclear power radiation is thyroid cancer, from information based on the 1986 Chernobyl accident in the Ukraine (Cardis, Richardson, & Kesminiene, 2001). More importantly, it has been shown that the people most likely to develop thyroid cancer from the radiation were individuals who were living in high risk areas near the nuclear power accident site, especially children, with an estimated ten-fold increase compared with non-exposed populations (Fuzik et al., 2011). The Chernobyl accident and aftermath demonstrate the long-term and detrimental effects that a nuclear power accident can have.

More recently, Cambra et al (2011) examined multiple health issues in the Basque area of Spain. Mortality rates were compared with the location of nuclear power plants and metal-processing plants in conjunction with census sections. Men living near energy processing plants had an increased risk of tracheal, bronchial, and lung cancer. In addition, men had an increased risk of lung cancer mortality if they lived within 1000 meters of an energy processing plant (Cambra et al., 2011).

In addition to research focusing on cancer, another important hypothesized health issue is the effect nuclear power plants may have on birth outcomes. Thus far, there has not been any substantive evidence for a link to negative birth outcomes but research has focused solely on immediate birth outcomes and has not taken into consideration other potential health issues that may arise later in a child's life (Wang, et al., 2010).

The possible health implications caused from living near a nuclear power plant is an area that still has not reached consensus (Wang, et al., 2010). The health effect of low doses of radiation is a topic that should continue to be studied in the future. However, currently evidence reveals that living near a nuclear power plant has minimal health implications, unless a Chernobyl-like disaster occurs.

Environmental Implications

This century has seen a rise in the observance of environmentally friendly practices. Nuclear energy is typically considered one of the more environmentally friendly sources of energy, except that plants require large amounts of water to be able to function and properly cool the reactive core (Garrick & Christie, 2002). The environmental effect of using large amounts of water at nuclear power plants has revealed mixed results, and has resulted in studies looking at ways to improve some of the effects of the discharged water, which can be an average of 7°C higher than in control areas (Teixeira, Neves, & Araujo, 2009). The effected water discharge areas change the natural environment by decreasing benthic cover, increasing the amount of bare rock, and increasing the number of opportunistic species. Chlorine added to the discharged water also contributes to the decreased habitat, which in turn, effects the fish population. The effects on the habitat of aquatic species due to discharged water from nuclear power plants is an example of thermal pollution (Teixeira, et al., 2009).

Efforts have been made in south China to reduce effects of nuclear power on the ecosystem. Assessments of the current state of the ecosystem as a whole were conducted to assess current efforts to reverse previous damage caused by water usage at a nuclear power plant (Chen et al., 2010). Although some positive changes were found, such as phytoplankton returning to original levels, the number of zooplankton and benthos continued to decrease. In this example, water quality worsened, sediment quality remained the same, the control of emissions was found to not be effective, and fishery resources were not restored. Priority areas for future restoration included habitat reconstruction, fisheries, coastal plants, and wastewater management (Chen, et al., 2010).

It is important to understand the effect that nuclear power plants can have on the land environment that surrounds them. Studies conducted both at functioning power plant locations, and at nuclear power plant accident locations have found minimal radiation in the soil and plants (Micieta & Murin, 2007; Wallberg & Moberg, 2002). The minimal radionuclides found in the surrounding

plant life bode well for the safety of nuclear power plants, and show that their effect on the land environment is minimal (Micieta & Murin, 2007).

Whereas the potential environmental effects of everyday operation of nuclear power plants have alarmed some individuals, there can be more confounding environmental concerns following serious accidents. The Chernobyl accident was a major catastrophe whose environmental issues are still mounting (Oskolkov et al., 2010). Although there has been no evidence of effects on the surrounding land environment, the accident did contaminate the cooling pond. If the pond begins to evaporate, it is thought that the radioactivity levels will exceed the maximum amount that is considered safe for animals (Oskolkov, et al., 2010). Although this prospect is considered hypothetical at this point in time, it is illustrative of the possible damage that can be manifested following a large-scale event (Oskolkov, et al., 2010). Large-scale nuclear power plant accidents can have different detrimental results that could cause radioactive isotopes to contaminate the environment, due to different types of accidents including melting of the core structures and rods (Guentay, Cripps, Jackel, & Bruchertseifer, 2005).

The last element of the environment that nuclear power plants have the potential to pollute is the air, through radionuclides dispersed during normal discharge (Holgye & Filgas, 2006). Radioactivity dispersed through the air has been measured by looking at the particles in nuclear power plant ventilation stacks, and the surrounding soil (Holgye & Filgas, 2006). Overall, research has shown that the particles discharged through the air systems of nuclear power plants have a minimal effect on the environment, with an insignificant amount of contamination to the surrounding environment and atmosphere (Holgye & Filgas, 2006).

Although most studies look at the effects that nuclear power plants have on the environment, it is also important to consider the effects that the environment can have on the safety of power plants (Kopytko & Perkins, 2011). Nuclear power plants are at risk of damage from flooding, wind damage, erosion, and above average temperature changes. Despite the safety measures required of nuclear power plants in the United States, a large scale weather event could render the safety features useless through loss of power, failed alarm systems, or failed communication systems (Kopytko & Perkins, 2011). The difficulty with designing nuclear power plants to deal with these safety issues is weather and nature related issues are not easily predictable. Even if they can be predicted it is difficult to know the amount of damage they may cause (Kopytko & Perkins, 2011). This is the issue that Japan is currently dealing with in the wake of the catastrophic Tsunami that occurred on March 11, 2011.

Fukushima

Following a 9.0 magnitude earthquake, and subsequent Tsunami, Fukushima Diiachi nuclear power plant lost power, and was unable to cool the reactors which resulted in radionuclides releasing into the water and land environments (Sample, 2011). Despite the power plant being able to withstand the earthquake and Tsunami due to existing safety measures, it was unable to function properly with the loss of power and generators (Hall, 2011). This disaster has resulted in a call for better emergency frameworks, including taking a systems approach instead of focusing on the power plant alone. By looking at other possible issues that may occur within the community, such as the closure of roads and inability to obtain needed supplies due to flooding, more comprehensive safety measures could be implemented (Bates, Valverde, Vogel, & Linkov, 2011; Park, Seager, & Rao, 2011). The Fukushima disaster has implications for unknown long term health and environmental effects (Christodouleas et al., 2011). One of the more immediate implications of this disaster is the policy changes occurring in other countries. Germany, for example, has begun to shut down different nuclear reactors with plans to decrease the reliance on nuclear power. The issue that occurs is the need to find an alternative power source, which most likely will result in increased reliance on oil or coal, and an increase in carbon emissions (Hall, 2011). There continues to be a lack of knowledge of the short and long term effects, along with policy implications following a disaster, and is an area that warrants further research especially in light of the current situation (Dauer, Zanzonico, Tuttle, Quinn, & Strauss, 2011).

Safety, Risk, and Future Policy

To prevent nuclear power plant accidents, countries have started employing new safety features. France is in the process of implementing an automatic nuclear aerosol monitoring system to alert authorities about possible nucleotides in the atmosphere (Abida, Bocquet, Vercauteren, & Isnard, 2008). This safety feature will also allow for the measuring of the plume, and to forecast the evolution of the plume, thereby decreasing the risk of potential atmosphere contamination.

In the case of a major accident, an evacuation or sheltering in process is usually ordered. Georgiadou, Papazoglou, Kiranoudis, and Markatos (2010) state that instead of using predetermined emergency response plans, a situation-specific algorithm should be employed. They encourage the use of a multi-objective optimization approach, an algorithm

approach that is fast and allows for a better approach to emergency response. This new approach will allow for a more suitable response to the situation that is occurring, and will reduce the risk if there is a nuclear power plant emergency (Georgiadou, et al., 2010).

Another possible solution to a nuclear power plant emergency is through the preemptive distribution of potassium iodide, a pill that reduces the risk of radiation side effects, to families in the potential high risk areas. Blando et al. (2007) conducted a study in New Jersey (United States) to develop a better protocol for potassium iodide distribution and found that people who went to the iodide clinic, had significantly increased knowledge about the use and effectiveness of potassium iodide compared with the control group (Blando, et al., 2007). Early distribution and education about potassium iodide may result in individuals having a quicker and more effective response if a nuclear disaster was to occur (Blando, et al., 2007). Potassium iodide, among other agrochemicals, has also been found to reduce the amount of radionuclides through plant uptake when applied to soil (Vandenhove & Turcanu, 2011).

One important consideration in constructing a nuclear power plant is the public opinion of individuals living near the site. Overall, in the United States, radiation from nuclear power plants is not as much of an issue in the public opinion as global warming, traffic, and loss of space due to power plant construction (Greenberg, 2009). Most Americans believe that receiving a chest x-ray exposes them to higher levels of radiation than living near a nuclear power plant but 41% still believe that living next to a nuclear power plant may expose them to harmful radiation (Bisconti, 2011). Despite mixed results on the public opinions of nuclear power plants most Americans do not believe them to be harmful and instead are more concerned with other environmental issues like traffic and global warming (Greenberg, 2009).

Despite past accidents, nuclear power has been found to be a low-risk source of energy. Probabilistic risk assessment of nuclear power showed nuclear power plants to be safe, using conservative estimates, and nuclear power plant are considered to have a high quality of life rating compared with other types of energy (Chatzimouratidis & Pilavachi, 2008; Cuttler, 2007; Garrick & Christie, 2002) Quality of life in this instance is based on accident fatalities, non-radioactive emissions, radioactivity, and land requirement. Nuclear power is also considered one of the top forms of sustainable sources of energy, second only to wind power, and is also considered to be one of the top sources of economically viable sources of power, second only to hydroelectric power (Diaz, 2001; Onat & Bayar, 2010).

Nuclear power plants have been found to be a relatively safe form of energy and only pose a risk when a serious accident occurs (Blevins & Andersen, 2011). One important consideration that has not been embraced as widely is building new nuclear power plants in safer environmental areas to combat potential damage due to extreme weather. Currently most nuclear power plants are built at existing sites to save money, despite the fact that these sites might not being the safest locations (Kopytko & Perkins, 2011). To protect the environment, and the individuals living near nuclear power plants, more attention needs to be paid to building on sites that are safe, even if they are less cost-effective.

Conclusion

Overall, properly functioning nuclear power plants pose little risk to the health of people, and to the environment, and can be considered a relatively cost-effective means of energy (Chatzimouratidis & Pilavachi, 2008). To reduce the risk that can arise from nuclear disasters, such as Chernobyl (1986), and more recently Fukushima (2011), increased precautions need to be followed. These precautions include increased safety measures, more comprehensive emergency planning, and safer power plant sites (Kopytko & Perkins, 2011). With advancing technology, and knowledge about ways to further protect individuals and the environment from nuclear power disasters, nuclear power plants have the potential to provide a more environmentally friendly source of energy, thereby contributing to environmental risk reduction.

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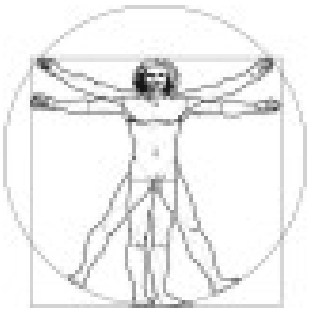

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