ISSN 2347-4289

Water Pollution Through Energy Sector

Lata Tripathi, A.K.Mishra, Anil Kumar Dubey, C.B.Tripathi

Research Scholar, Rajiv Gandhi Prodyogiki Vishwavidyalaya, Bhopal, MP, India-462033
Professor & Head, Chemistry Deptt., Rajiv Gandhi ProdyogikiVishwavidyalaya, Bhopal, MP, India-462033
Principal Scientist, Central Institute of Agricultural Engineering, Bhopal, MP, India-462038
Senior Technical Officer, IGFRI, Jhansi, India-284003
lata_mudgal@yahoo.co.in, ak_mishra01@yahoo.co.in, dubey@ciae.res.in, cbtripathi@rediffmail.com

Abstract: Energy and water are valuable resources and are to a large extent, interdependent. Water is an integral element of energy resource development and utilization. It is used in energy-resource extraction, refining & processing and transportation. There are different sources of water pollution in which energy sector play major role. Due to population growth and economic development, demand of energy is increasing continuously which ultimately affected the quality of water. Depending on the water quality needs for particular applications, freshwater supplies can be augmented with degraded or brackish water. Water quantities available for use are dependent on the water qualities needed for each use. In a present energy scenario, consumption of water in the electric sector could grow substantially, though increased demand for water would provide an incentive for technologies that reduce water use, thus dampening the increase in water use. Technologies are available that can reduce water use in the electric sector, including alternative cooling for thermoelectric power plants, wind power, and solar photovoltaics, but cost and economics, among other factors, have limited deployment of these technologies Meanwhile, climate concerns and declines in groundwater levels suggest that less freshwater, not more, may be available in the future.

Keywords: Energy, water pollution, energy scenario, ground water

1. Introduction

Water is an essential source of all living organism after air, which is in plenty on the earth and covers about 70% of earth's surface. The amount of water present on earth is estimated at about 1.39 billion cubic kilometer, of which only about 2.5% is fresh water. The other part i.e. 97.5% is sea or brackish water unsuitable for human use [2]. The amount of fresh water available to humankind is about 0.29 to 0.49 % of total surface water therefore its treatment and recycling is very important [14]. With increased population and urbanization, our demand for freshwater and energy will continue to increase. International Energy Agency (IEA) estimates show that by 2035, global energy consumption will increase by 35%. In developing Asia, water used for energy production will increase from 157 billion cubic meter (bcm) in 2010 to 230 billion cubic meter (bcm) by 2035. This is a very steep increase. As a finite resource, water is a potentially binding constraint on enhancing energy security in the region. Unless it is strategically conserved and efficiently managed, increased use of energy leads to increased emissions of greenhouse gases, which will accelerate the negative impacts of global climate change. These impacts are primarily water-related, as evident from the growing frequency of extreme hydro-climate events, such as cyclones, floods, and droughts. These in turn have adverse social, economic, and environmental consequences. Day to day the demand of electricity supply and safe suitable water for drinking is going to be incises in India. Environmental conditions play an important role in the settlement, growth, distribution, reproduction and survival of aquatic animals. It has a great impact on the life of organisms with its different physical and chemical properties [15]. Further, impacts resulting from global climate change have added a new dimension to management of emerging water crisis [11]. Elements of a water crisis may put pressures on affected parties to obtain more of a shared water resource, causing diplomatic tension or outright conflict.11% of the global population, or 783 million people, are still without access to improved sources of drinking water, which provides the catalyst for potential for water disputes. Besides life, water is necessary for proper sanitation, commercial services, and the production of commercial goods. Thus numerous types of parties can become implicated in a water dispute. For example, corporate entities may pollute water resources shared by a community, or governments may argue over who gets access to a river used as an international or inter-state boundary and due to overcome of water crisis there is a proposal of interlinking of different rivers. Water is used for agriculture, drinking, industries, laundry, recreation and fisheries from different sources like lakes, ponds, rivers and reservoirs. The industrial growth and consequent pollution let into the fresh water bodies to clean themselves has affected by the sheer quantity of waste generated by ever increasing population [6,20]. Water is also an integral part of electric-power generation. It is used directly in hydroelectric generation and is also used extensively for cooling and emissions scrubbing in thermoelectric generation. However, as population has increased, demand for energy and water has grown. Competing demands for water supply are affecting the value and availability of the resource [18].

2 Water Availability and Uses:

In India total availability of water from different resources has been estimated to be about 1123 Billion Cubic Meter (690 BCM from surface and 433 BCM from ground).About 85% (688 BCM) of water is used for irrigation (Figure 1), which may increase to 1072 BCM by 2050. Major source for irrigation is groundwater. Annual groundwater recharge is about 433 BCM of which 212.5 BCM used for irrigation and 18.1 BCM for domestic and industrial use [1]. By 2025, demand for domestic and industrial water usage may increase to 29.2 BCM. Thus water availability for irrigation is expected to reduce to 162.3 BCM. Due to increasing population and increasing demand of water in energy sector, the per capita average annual freshwater availability has been reducing since 1951 from 5177 m^3 to 1869 m^3, in 2001 and 1588 m^3, in 2010. It is expected to further reduce to 1341 m^3 in 2025 and 1140 m^3 in 2050. [10]. Hence, it is necessary to search the effective treatment option to enhanced water use efficiency and waste water recycling.

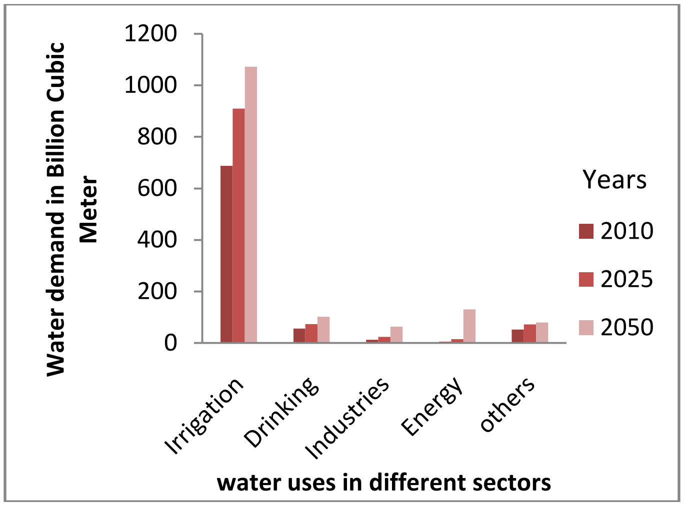

Figure 1: *Projected water demand by different sectors (CWC, 2010)[5]*

Water demand is continuously increasing in different sector. For irrigation and drinking purpose water demand is increasing 1.2-1.4 folds whereas in industries it increases 2-3 times but in energy sector its demand will be increasing 3-8 times in coming year due to continuously energy demand and establishment of different power plants in country.

3. Water Requirement through Different Energy Sources

Mostly energy requirement is fulfilled by thermal power plant, nuclear power plant and renewable energy based power plant. According to CEA report November 2014 [7], total installed capacity of power plant in the country stands at 255.01 GW in which, Thermal power accounts for 69.5 %, Renewable energy accounts for 12.5% Nuclear 2% and hydro holds a 16% percent share therefore thermal power plant play major contribution in water pollution. Thermal power plants that run on coal and other fossil fuels introduce a myriad of chemicals for maintenance or operational purposes, and through combustion, liberate other chemicals from the fuel that wind up in the power plant's discharge. Nuclear power plants consume even more water than fossil fuel facilities because of the additional cooling requirements of reactor cores and can have major impacts on marine environments. By contrast, Many renewable energy technologies such as wind and solar photovoltaic technology produce electricity without generating any waste effluent released into waterways or without relying upon any cooling water.

Water consumption of different energy sources: (litres per kilowatt-hour of electrical output)

Sources	Water consumption in litres per kilowatt-hour of electrical output
Nuclear	2.5
Coal	1.9
Oil	1.6
Combined Cycle Gas	0.95
Solar PV	0.11
Wind	0.004

Source:*http://www.foe.org.au/sites/default/files/Water-NP-2xA4-2013.pdf[9]*

3.1. In Thermal Power Plants

The current installed capacity of thermal power plants (including coal, nuclear, oil/diesel) till November 2014 stands at around 177741.89 MW its share in electricity generation is 69.5% [7].The water requirements for a coal-based power plant is about 0.005-0.18 m^3/kWh. At STPS, the water requirement has been marginally reduced from about 0.18 m^3/kWh to 0.15 m^3/kWh after the installation of a treatment facility for the ash pond decant. Still the water requirement of 0.15 m^3/kWh per Unit of electricity is very high compared to the domestic requirement of water of a big city. The high ash content in India's coal affects the thermal power plant's potential emissions. Ash from power plants directly affects the irrigation land and water sources of nearby area [17].

3.2 In Nuclear Energy

Water for a nuclear power plant can be sourced from a river, lake, dam, or the ocean. The water has two uses - it is converted to steam to drive a turbine, and cooling water converts the steam back to water. Nuclear power plants consume large amounts of water – typically 13-24 billion litres per year, or 35-65 million litres per day. Depending on the cooling technology utilised, the water requirements for a nuclear power station can vary between 20 to 83 per cent more than for other power stations. A megawatt-hour (MWh) of electricity from coal uses 20 to 270 litres of water at the coal mining stage and an additional 1,200 to 2,000 litres when the energy in the coal is converted to electricity, totalling 1,220 to 2,270 litres of water consumed per MWh. In comparison, nuclear energy uses 170 to 570 litres of water per MWh during the mining of uranium and production of the reactor fuel and an additional 2,700 litres per MWh as the energy from nuclear fission is converted to electricity, for a total of 2,870 to 3,270 litres of water consumed per MWh [19].

3.3 In Renewable Energy

Wind, hydro, solar, and biomass are the main sources of renewable energy. Water requirements for renewable electricity generating technologies range from negligible to comparable with thermal generation using wet tower cooling. Non-thermal renewables, such as wind and solar photovoltaic (PV) may use very small amounts of water, such as for cleaning or panel washing. Concentrating solar thermal plants (CSP), like all thermal electric plants, require water for cooling. Water use depends on the plant design, plant location, and the type of cooling system.CSP plants that use wet-recirculating technology with cooling towers withdraw between 600 and 650 gallons of water per megawatt-hour of electricity produced. Dry-cooling technology can reduce water use at CSP plants by approximately 90 percent [13]. Hydropower is a major water user, relying on water passing through turbines to generate electricity. Water is consumed via seepage and evaporation from the reservoir created for hydropower facilities. Factors determining the amount consumed – climate, reservoir design and allocations to other uses – are highly site-specific and variable[16]. Biomass power plants and coal power plants require approximately the same amount of water for cooling, amount of water withdrawals and consumption depends

ISSN 2347-4289

on cooling facility's technology. For biomass power plants, water withdrawals range for cooling between 20,000 and 50,000 gallons per megawatt-hour with consumption of 300 gallons per megawatt-hour. Biomass facilities that use wet-recirculating cooling systems—which reuse cooling water in a second cycle rather than immediately discharging it—withdraw between 500 and 900 gallons per megawatt-hour and consume approximately 480 gallons per megawatt-hour [12].

4. Interlinking between Water and Energy

Water is required to produce nearly all forms of energy. For primary fuels, water is used in resource extraction, irrigation of biofuels feedstock crops, fuel refining and processing, and transport. In power generation, water provides cooling and other process-related needs at thermal power plants; hydropower facilities harness its movement for electricity production [18]. The use of water in these energy sectors adversely affects the quality of water by contamination. Use of water in different energy sector for different purpose and its effect on water quality is shown in table 2.

Table-2 Key uses of water for energy and potential water quality impacts [18]

Primary energy production	Uses	Potential water quality impact
Oil and gas	• Drilling, well completion and hydraulic fracturing • Injection into the reservoir in secondary and enhanced oil recovery. • Oil sands mining and in-situ recovery. • Upgrading and refining into products	Contamination by tailings seepage, fracturing fluids, flow back or produced water (surface and groundwater)
Coal	• Cutting and dust suppression in mining and hauling. • Washing to improve coal quality. • Re-vegetation of surface mines. • Long-distance transport via coal slurry.	Contamination by tailings seepage, mine drainage or produced water (surface and groundwater).
Biofuels	• Irrigation for feedstock crop growth. • Wet milling, washing and cooling in the fuel conversion process.	• Contamination by runoff containing fertilisers, pesticides and sediments (surface and groundwater). • Wastewater produced by refining.
Thermal (fossil fuel, nuclear and bioenergy)	• Boiler feed, *i.e.* the water used to generate steam or hot water. • Cooling for steam-condensing. • Pollutant scrubbing using emissions-control equipment.	Thermal pollution by cooling water discharge (surface water).Impact on aquatic ecosystems. Air emissions that pollute water downwind (surface water).Discharge of boiler blow down, *i.e*. boiler feed that contains suspended solids
Concentrating solar power and geothermal	• System fluids or boiler feed, *i.e.* the water used to generate steam or hot water. • Cooling for steam-condensing	.Thermal pollution by cooling water discharge (surface water). Impact on aquatic ecosystems
Hydropower	• Electricity generation. • Storage in a reservoir (for operating hydro-electric dams or energy storage).	• Alteration of water temperatures, flow volume/timing and aquatic ecosystems. • Evaporative losses from the reservoir

5. Effects of Power Plant Effluents

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries like India, energy consumption has been increasing at a relatively fast rate due to population growth and economic development. Power plant also play major role in water pollution. A typical 500-megawatt coal power plant creates more than 125,000 tons of ash and 193,000 tons of sludge from the smokestack scrubber each year. Generally, more than 75% of this waste is disposed of in unlined, unmonitored onsite landfills and surface impoundments. Toxic substances in the waste - including arsenic, mercury, chromium, and cadmium can contaminate drinking water supplies and damage vital human organs and the nervous system. One study found that one out of every 100 children who drink groundwater contaminated with arsenic from coal power plant wastes were at risk of developing cancer. In the case of hydroelectric plants water environment is affected due to the stagnation of water in the reservoir. If the reservoir accumulates runoff from agricultural fields, the water may contain high amounts of fertilizer and pesticide residues, which may accumulate in the reservoir. Major pollutants due to coal based power generation include sulfur dioxide, carbon and nitrogen compounds, non-combustible hydrocarbons, heavy metals and fly ash [3].

ISSN 2347-4289

6. How can overcome the problem of water requirement

Waste water from electricity sector contributes to water pollution. Thermal and nuclear power plant waste water usually contains specific and readily identifiable chemical compounds. During the last few years, the number of power plant in India has grown rapidly. But water pollution is concentrated within a few subsectors, mainly in the form of toxic wastes and organic pollutants. Most major industries have treatment facilities for industrial effluents. Only 60% wastewater generated by industries is treated. In case of small scale industries that may not afford cost of waste water treatment plant, Common Effluent Treatment Plants (CETP) has been set-up for cluster of small scale industries [4]. The treatment methods adapted in these plants are dissolved air floatation, dual media filter, activated carbon filter, sand filtration and tank stabilization, flash mixer, clariflocculator, secondary clarifiers and Sludge drying beds, etc. But small-scale industries cannot afford enormous investments in pollution control equipment as their profit margin is very slender. Overall analysis of water resources indicates that in coming years, there will be a twin edged problem to deal with reduced fresh water availability and increased wastewater generation due to increased population and industrialization. Due to increase demand of water in electricity generation, it is the challenge to developed and developing nations for management and recycling of waste water [11]. Therefore several opportunities are available to improve the situation. In the power sector, these include greater reliance on renewable energy technologies that have minimal water requirements, such as solar PV and wind; improving the efficiency of power plants, for instance by shifting from subcritical coal to supercritical coal or IGCC plants; and deployment of more advanced cooling systems, including wet cooling towers, and dry and hybrid cooling. In biofuels production, biomass crops and locations that have the greatest water efficiency will be advantaged. More generally, the energy sector can look to exploit non-freshwater sources – saline water, treated wastewater, storm water and produced water from oil and gas operations – and adopt water re-use technologies. Importantly, assigning precious water resources a more appropriate economic value in regions where it is underpriced or even free would encourage more efficient use, not only in the energy sector but across the economy.

7. Conclusion

There is no doubt that water is growing in importance as a criterion for assessing the physical, economic and environmental viability of energy projects. Water and energy both are necessary for development and are interlinked. Therefore better and cost effective technologies of water treatment will need to recycle the waste water of energy sector to reduce the availability of fresh water in this sector so that both can be available to each.

References:

[1] CGWB. 2011. Ground Water Year Book - India 2010-11. Central Ground Water Board, Ministry of Water Resources. Government of India.

[2] Chatterjee Sisir (2009). A Geographical study on drinking water management in Shimla municipal area, Himachal. Everyman's Science. Vol. XLIV, No. 2.

[3] Chowdhury Abdullah Harun "Impact of coal based power plant at Rampal" Khulna University.

[4] CPCB. 2005. Performance status of common effluent treatment plants in India. Central Pollution Control Board, India.

[5] CWC. 2010. Water and related statistics. Water Planning and Project Wing, Central Water Commission, India.

[6] Ghosh, G.K. (1992). Environmental Pollution. A scientific dimension. Curr. Sci. 30, 265 – 269.

[7] http://www.cea.nic.in/reports/monthly/inst_capacity/Nov.14.pdf

[8] http://www.unescap.org/speeches/water-energy-lifelines-sustainable-prosperity.

[9] http://www.foe.org.au/sites/default/files/Water-NP-2xA4-2013.pdf

[10] Kaur R, Wani SP, Singh AK and Lal K "Wastewater production, treatment and use in India" http://www.ais.unwater.org/

[11] Kodarkar, M.S. (2008). Conservations of lakes. Indian Association of Aquatic Biologists, Hyderabad, 76p.

[12] Macknick, et al. 2011A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies. Golden, CO: National Renewable Energy Laboratory.

[13] National Renewable Energy Laboratory's Renewable energy Data book 2012 (NREL)

[14] Patil, A.R. and Lohar, P.S. (2009). Seasonal variations in physico-chemical parameters of river Patalganga, Raigad district, Maharashtra. J. Aqua. Biol., 24(2), 109 – 112 .

[15] Swami, B.S. and Udhayakumar, M. (2007). Observation on seasonal variations in hydroFigure Noical characteristics recorded at Mumbai harbour. Eco. Env. and Cons. 13(2), 383 – 394.

[16] [Torcellini, P., N. Long and R. Judkoff (2003), *Consumptive Water Use for US Power Production*, National Renewable Energy Laboratory, Golden, United States.

ISSN 2347-4289

[17] W. K. Pokale, “Effects Of Thermal Power Plant On Environment,” Sci. Revs. Chem. Commun.: 2(3), 2012, 212-215.

[18] “World Energy outlook 2012” http://www.iea.org/publications/freepublications/publication/english.pdf

[19] www.foe.org.au/anti-nuclear January 2013

[20] Zaheeruddin and Shadab Khurshid (1998). Dispersion of heavy metals and its toxic effects on water quality in the parts of Faridabad, Haryana. J. Ecotoxicol. Environ. Monit., 8(1), 9 – 14.