

CHAPTER THREE

Semiconductor production process and pollutions in Hsinchu Science Industrial Park

1.1 Impact of semiconductor production

The environment damage cause by the production of high tech industry has began to surface in the late 90s, as can be seen from Table Five in chapter 2, high tech industry with support of the government had developed very fast, however the development of infrastructure can not catch up with the production speed of the industry, at same time the lack of water and unstable electricity intensified the environmental problems.

Often Capitalist is unwilling to pay for the construction of the infrastructures, why should they when paying for it would means increase in cost, and the capital knows no national boundaries, when the going gets tough, Capitalist can find production site at another location which provides cheap labor, little or no environmental regulation and supportive government. Governments no matter how big or small facing the

problem of migrating investment since with it comes migration of job opportunity¹, which had been the cause of much heated political debate. When economy downturn and Capitalists reallocate investment and outsourcing the jobs, often Capitalists would have more bargain power and they were able to engage in the rent seeking activities. As Capitalists lobbying for political favor with government officials, politicians and bureaucrats exploit their current opportunities to manipulate the existing environmental framework so that in future it serves their own private interests². And often the private interest could be money changing hands, or exchange of personal favor between bureaucrats and Capitalist. As politicians conspire with Capitalists, it becomes difficult for government to maintain their stand on the environmental issue. In 2001, President Chen went to inspect Quanta Display Inc. (廣輝電子), a company that produce Thin Film Transistor Liquid Crystal Display³, during the visit he criticized local government's requirement for the environmental impact assessment were too high and it had become the obstacles of state construction and development of the firms. He said that barriers that have negative impact on the corporal efficiency and development should be removed, and he went as far as saying that he was willing

¹ "GE Execs Hear Complaints from Retirees at Annual Shareholder Meeting." *Associated Press*. 29 Apr. 2004. 3 Jul. 2004 <<http://www.globalaging.org/elderrights/us/2004/complain.htm>>

² Ohlsson, Lief. "Concepts & Issues: Rent Seeking – general features." *Environmental & Development Challenges*. 3 Jul. 2004 <<http://www.edcnews.se/Research/RentSeeking.html>>

³ *Quanta*. Quanta Display Inc. 3 Jul. 2004 <http://www.qdi.com.tw/index_01.htm>
Thin Film Transistor Liquid Crystal Display can be use as screen of personal computer, PDA, cell-phone, GPS etc. As Taiwan is now the largest producer of Notebook and Monitoring equipment, the Taiwan market share of TFT-LCD would likely to reach 43.58% in 2004, exceed world's largest producer Korea.

to beg on his knees on behalf of the corporations⁴. Soon after that, during the Economic Development Advisory Conference, for the purpose of “mediate the relationship between environmental standard, labor law and industrial development”, it was decided that no environmental impact assessment is needed when apply for permission in established production facility in Industrial Park, Science Industrial Park or export processing zone, if the pollution is not exceeded the total allocated amount for the Industrial Park. At same time officials should actively encourage investment by the firms, and remove barriers to investment. This new decision is against Environmental Assessment Law, under this regulation, which came into effects in 1995, it stated that all firms in printed circuit board industry and semiconductor industry which wanted to build plant in Tap water quantity and quality protection zone or within city limit and construction site is larger than 5 hectare have to conduct environmental assessment⁵. And the environment assessment should be done in the plan stage of the project, after the environmental assessment had pass by officials, than they could be given the pollution and waste management related permits. Than firms could apply for construction, utilization permits as well as permission to establish production facility⁶. It is clear that this decision will benefit

⁴ “Economy guilty? – Is sacrifice environment for economy necessary evil?” Environment Information Electronic Paper. 3 Jul. 2004 <<http://mx.nthu.edu.tw/~hycheng/2green/2001All.html>>

⁵ *Environmental Regulations*. EPA Executive Yuan. 3 Jul. 2004 <http://w3.epa.gov.tw/epalaw/index.htm>

⁶ Chen, L. C., *High-Tech Fantasies: Hsinchu Science-based Industrial Park and Local Development*. Taipei, 2001.

the Capitalist at expense of the environment and workforce, however as economy facing downturn at that moment due to the Asia crisis, and lack of faith in the economic leadership of new DPP government, which resulted in government not able to withstand the pressure from the industry to lower the environmental regulations.

As Taiwan have weak labor movement, workers' demand often went unheard and society expected worker to sacrifice for economic development. As workers did sacrifice for "greater good" of economic, they accepting lower wages, less benefits, and harsher working condition from deregulation, especially in the semiconductor industry where workers are subject to occupational hazard of waste chemical from production process. In order to manufacture an eight inch wafer made up of hundreds of chips, on average would produce 9 pounds of hazardous waste and 3787 gallons of waste water, during the production workers would handle 27 pounds of chemicals and 29 cubic feet of dangerous gases. As result of the highly corrosive hydrochloric acid and hazardous solvents (such as methyl chloroform, toluene, benzene, acetone and trichloroethylene) used in the semiconductor industry, the worker in this industry have a rate of occupational illnesses resulting in lost workdays that is twice as high as that of workers in other manufacturing sectors⁷. As there is no specific production formula

⁷ U.S. Department of Labor's Bureau of Labor Statistics. Apri. 1999.

used in the semiconductor industry, workers are exposed to combination of chemicals, as the materials used in production are trade secret, it is difficult to monitor the occupational hazard in the sector.

Study had showed that the probability of miscarriage for female worker who handle chemicals such as glycol ethers in the silicon wafer manufacturing sector were 14%, while the female workers whom work in the same industry but do not handle such chemicals have miscarriage rate of 10%⁸.

Silicon Valley is the most famous and successful IT center in the world, it has the most semiconductor firms in the United States. In the 1950s, Stanford Industrial Park was established, the ideal behind the park was “center of high technology close to a cooperative university”⁹, and company have to share technology with university to be able to located in the park.

With the invention of the transistor¹⁰, silicon was chose to act as the base to the microchip. The Stanford Industrial Park later becomes Silicon Valley because the extensive use of silicon in the semiconductor production, silicon was chose because of

⁸ Chepesiuk. “Where the chips fall: Environmental health in the semiconductor industry.” *Environmental Health Perspectives* 107 (1999): 452-458

The study done by the researchers at the University of California resulted in the removed of glycol ethers from production in the semiconductor industry.

⁹ Carolyn E. Tajnaj

¹⁰ *Transistor*. Webster dictionary. 1 Apr. 2004

<<http://www.webster-dictionary.org/definition/transistor>>

With transistor, switches on a solid semi-conducting device are throwing electrically outside of the vacuum tub.

it's stability and can endure high temperature. It is the second most excess substance on Earth. Raw Silicon does not exist in nature, when combine with oxygen it make up seventy five percent of the Earth's crust (sand, mineral, quartz etc.). The raw material used in the chip production such as silicon, oxygen, solvent and metals etc. are relatively low in cost. The most of the costs are in the innovation of the technology and facility and equipment cost, but the value of the final product are relatively high, which means the profit margin of the chip are large. Potential profit is the incentive for the firms to enter into market. As US firms became less competitive in the production of semiconductor chips, the production began to outshift to the develeoping countries, and the environmental pollution of this production was bought to the new production site as well. When those firms and facilities shift, they would be moving to a countries with less government regulations and where environment is not on the priority list. As firms leave they will be leaving behind all the pollution cause by the production behind and when they reach new country, pollution will be start over again. As we all occupied one planet, pollution issue is of global concern, the organic vapors (like Benzene, Methylbenzene, Trichloroethylene, Trichloroethane and Xylenes) lease into the atmosphere have effect on the ozone layer, and that in terms have effect on entire population.

The Silicon Valley has most concentrated Superfund site in the USA, total of 29 Superfund site could be found, and 20 out of which is cause by the semiconductor production (Mazurek, 54). The pollution in California was very serious, in the study conducted by Silicon Valley Toxic Coalition in 1986 show that 80% of the underground storage tank was damage and hazardous organic solvent was leaking from it, and this has contaminated 200 public and private wells. The ground water was contaminated as the result, up to 100 chemicals was found in the ground water. The hazardous waste generated by the semiconductor production reach 100 thousand tons per year and 3860 ton was discharge into the environment (Yoshida, 15).

Prior to 1981, health problem in the US semiconductor workers had been dismissed as inconsequential. However by 1984, Professor LaDou publish an article about the occupational injuries among the semiconductor workers, he found that the semiconductor production was not safer than other industries, and he believe that the information provided by government are not to be trust. Numerous dangerous chemicals used in the semiconductor production, and chemicals are mixed, heated to undergo chemical reactions. Workers are expose to those highly toxic chemicals, and because the effect of those chemicals on human are unknow due to the lack of study, and today study had show that some of the chemicals used are likely to cause human carcinogen

It was not until 1999 a study of cancer risk among workers in the U.S. semiconductor industry was attempted¹¹, it was conducted by the Scientific Advisory Committee, and which was appointed by Semiconductor Industry Association, however after one year and half committee could not find definite evidence of increasing risk of cancer among U.S. semiconductor factory workers, the funding is inconclusive because of the insufficient data. Scientific Advisory Committee (SAC) suggested Semiconductor Industry Association (SIA) that if there is enough data then backward epidemiology study on the potential cancer risk to semiconductor workers should be conducted.

Also the health surveillance should be improved, and the findings should be provided to members. By 2002, Semiconductor Industry Association accepted recommendation of SAC, and the study was implemented in 2003. SIA and Johns Hopkins University Bloomberg School of Public Health conducted separate research on whether there is enough information to carry out backward epidemiology study, in the end both parties agree that there is enough data. But when will the retrospective epidemiology be done is still uncertain, at the same time the accuracy and fairness of the study is also questionable since SIA will choose the investigator and the result will be reviewed by SIA, whom is likely to be biased. As of today, there is only two studies done on the cancer risk among workers in the semiconductor industry, one is by U.K. Health and

¹¹ *SIA worker health project*. Semiconductor Industry Association. 4 Jul. 2004
<http://www.sia-online.org/iss_whs.cfm>

Safety Executive¹², other one is by IBM. The finding in the study done by Health and Safety Executive indicted that work related risk of cancer is possible in the semiconductor industry, and IBM findings seems to indicate that there is no risk of cancer in it's workers¹³, however after the distinguished epidemiologist Richard Clapp, of Boston University, and his colleague Rebecca Johnson had examined the IBM employee mortality records (which IBM was force to hand over under the court order, and they maintain that it does not have useful data), they found that IBM workers who worked in the chip manufacturing plant suffer more death from cancers (brain and kidney cancers and non-Hodgkin's lymphoma) than that of the general population.

In the past 10 years, cancer had become the number one cause of death; about 25% death cause by cancer, more and more study had point out that the cause of cancer could be of polluted environment. In the study done by the Department of Health Executive Yuan between 1982-1991, a map of the cancer distribution in Taiwan area was plotted, it showed that the cancer clusters occurs in the township of the Taiwan western plain. Next to those townships, there were heavily polluted rivers or industrial

¹² McElevenny, Damien M., Andrew Darnton, John Hodgson, Simon Clarke, Richard Elliot, and John Osman. *Cancer Among Current and Former Workers at National Semiconductor (UK) Ltd, Greenock: Results of an Investigation by Health and Safety Executive*. Norwich: Her Majesty's Stationery Office, 2001.

¹³ IBM workers alleged that they were exposed to cancer causing chemical during work, and there were at least 100 cases against IBM pending in New York, Minnesota etc. As most cases against IBM are settling out of court, it has show that causal link is very difficult to prove.

park, and the types of cancers are the ones that's most likely to cause by environment for example hepatoma, gastric carcinoma, lung cancer, kidney cancer, bladder cancer, cervical cancer, breast cancer, leukemia, colorectal cancer, prostate cancer¹⁴. The 32 out of 55 townships, which have the highest death rate, are situated in the downstream of rivers. In a study done by Dr Ge¹⁵, 20% of the cancers were caused by the environmental pollutions, however as the latent period of cancer is about 10-20 years, it is difficult to prove the causal link and if the case is taken to court it is hard to eliminate the direct evidence of other factors. As of today, Taiwan semiconductor industry had been developed for 24 years, there is still no study done on the risk of cancer among Taiwan semiconductor factory workers. As the effects of semiconductor production were profound and long lasting, it does not only affect the semiconductor workers but the general public as well. With example of Fairchild and IBM in the United States, Taiwan should conduct researches on the risk of cancer among Taiwan semiconductor factory workers, as there were nearly a million people who work in the high tech or related industry¹⁶ by the end of 2001, the epidemiology of the workers in the semiconductor industry is necessary and unavoidable. Pollution by semiconductor

¹⁴ The types of cancer the former RCA workers were diagnosed with were hepatoma, lung cancer, kidney cancer, bladder cancer, cervical cancer, breast cancer, prostate cancer, and leukemia.

¹⁵ Ku, I. C. & Z. N. Wong. Meaning of the death by illness of Taiwan Community. Kaohsiung City: Morality, 1996.

Dr. Ge is a professor of Epidemic in Kaohsiung Medical School, and has been research on the relationship between occupations, environment cause of cancer.

¹⁶ "Study of Taiwan Manufacturing sector (1)" 2001 industrial and service sector report. 5 Jul. 2004 <<http://www.dgbasey.gov.tw/census~n/two/FILE/INDU/C/summary.htm>>

industry is a fact and has serious implications, epidemiology could help us decide what kind action should be taken and increase the awareness of the people to the cancer epidemic. The semiconductor industry has a duty to society to investigate the increasing risk of cancer among Taiwan semiconductor workers since workers had contributed great deal to the development of Taiwan semiconductor, which had made corporations like Taiwan Semiconductor Manufacturer and United Microelectronics famous and largest supplier of semiconductor parts in the world market. As Taiwan lack a large domestic market to retain the corporations, those corporations shift their production sites to China, they leave behind destruction environment damage and damage labor relationship. As the gain of semiconductor production is build on decrease consumer gain and increase dead weight loss on society, it is not fair or just to make society bear the burden of environmental cost.

3.2 The production of Integrated Circuit

Taiwan is an industrialized country, with export-oriented policies; most of the industrial products were exported overseas. In the 90s, high tech industries, semiconductor, PC etc. had become the dominate export industries, with production

value reach one trillion last year, it is the hen that lays the golden egg. The high tech industry had always presented a clean and green image, also it is a highly profitable industry; they argue that their presence was good for economic growth and assisted with environmental recovery. However the production of the IC required area that were completely without contaminations, therefore they could not be produce at any location, specific fab had to be constructed, in which satisfactory IC could be constructed. Taiwan is a small island with area of approximately 36,000 square kilometers¹⁷, but it houses 56 fabs build by 36 semiconductor and/or IC companies¹⁸. Although Taiwan is only slightly smaller than Netherlands, its production capacity exceeds U.S., German, Italy, England, Ireland and Netherlands. Taiwan's production capacity of 300mm is 29% of total world production while the second in line United State is only 19%. Taiwan Semiconductor Manufacturing Co., and United Microelectronics Corp., is the largest foundries in the industry, they had rapid growth in the past 10 years, from 3% of industry capacity in 1995 to the 22% this year. In order to construct fab, it takes 10 engineer 6 months to design and 500 contractors 12 months to construct. The concrete use to construct one fab could build a road 15 miles in length, as well as using 3000 miles of steel, by the time it is complete it is big

¹⁷ From Government Information Office, Republic of China (Taiwan). Q&A about ROC. July 2004.

¹⁸ Burns, George. "Taiwan: An Island of Continental Dimensions" Semiconductor International. (2004)

<<http://www.keepmedia.com/pubs/SemiconductorInternational/2003/09/01/274611?extID=10026>>

enough to contain 36 football fields (Mazurek, 29). When in operation, the electricity it needed would be enough to power 7500 homes and water used in production had to be 2000 times purer than the tap water, and amount of water used per day is about 6.7 million gallons¹⁹. In total the price of building a fab is about 5 billion dollars in 2000, 75% of which is spend on the production equipment, and it is made by different manufacturer around the world. As Taiwan Semiconductor Manufacturer and United Microelectronics spend around 7 billion dollars on capital equipment in 2000, which was about 64% of total investment in Taiwan that year. Although Taiwan is already over producing at present rate, 13 more fab is planned for the next 2 years. As semiconductor industry do have large capital investment, and could possibly stimulate economic growth, it comes with large social cost on the environment and people that live on this land as well.

In order for the production to be constant, stable supply of the main ingredients of IC like water and electricity is very important. Water Resource Agency under the Ministry of Economic Affairs (經濟部水利局) had planned to construct 2 major dams near the Science Industrial Park, to provide constant water source. Bao Shan in

¹⁹ *Topical Reports Energy and Water Efficiency for Semiconductor Manufacturing*. Pacific Northwest Pollution Prevention Resource Center. 3 Jul. 2004
<<http://www.pprc.org/pprc/pubs/topics/semicond/semicond.html>>

Hsinchu and Mei Nong near Tainan, those dams were among much controversies²⁰, most criticism were about the disregard of the public opinion and environmental impact of the dam construction, at same time the energy source had also been the subject of much debate. Those projects by government were benefiting the Capitalist more than the local residence, but costs of the projects were carry by the society at large.

As mentioned before the production of IC chips required large amount of materials to ensure purity, but most of those input materials were not included in the final product.

And the input materials used in production included extensive chemicals and gases, which in the end would become hazardous industrial waste, often the treatment of those hazardous waste were above the mean and ability of the related institute to deal with them. The production phases of the IC chips are the following (Van Zant 15-24):

²⁰ *Consequence of building Mei Nong Dam*. Mei Nong People's Association. 10 Jul. 2004

<<http://mpa.ngo.org.tw/why-no-dam/reseaon/reseaonindex.htm>>

Kondolf, G.M., & C. R. Ho. *Mei Nong Dam: Impossibility of sustainable growth in Taiwan*. Taiwan Environmental action Network. 10 Jul. 2004

<http://tean.formosa.org/article/report21-dam-jeff.html>

Chang Mi Dam. Tai Chung Information Net. 10 Jul. 2004

<<http://www.tcppa.org.tw/BID/980802~4.htm>>

Mei Nong Dam is a controversial project, since all the environmental group was against it, they believed that

1. The Dam was build for the benefit of the nearby Industrial Zone.
2. The natural landscape was unstable to the dam construction, and site of the project was very close to the village could endanger villagers live.

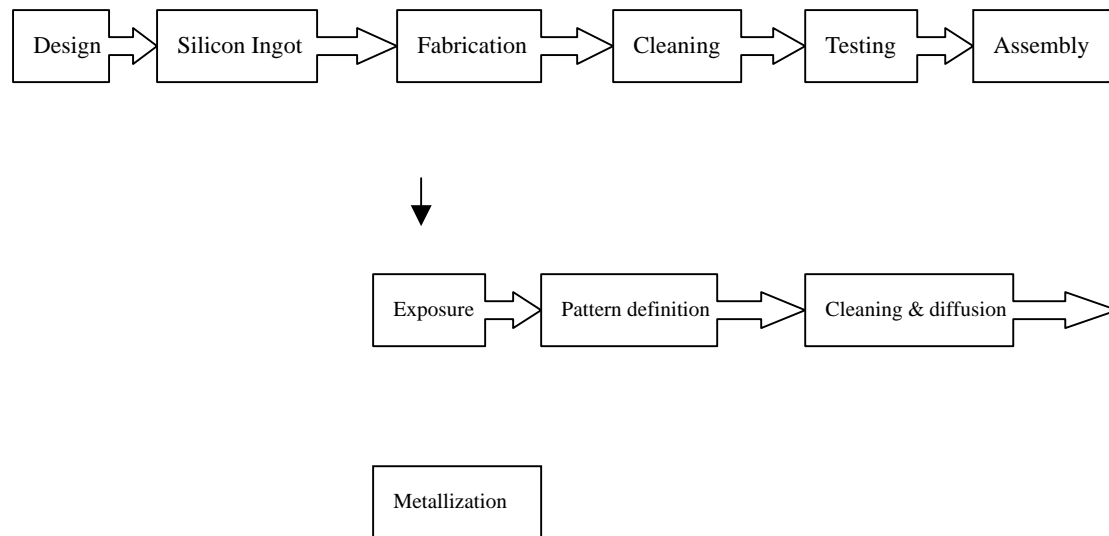
3. It could destroy the Hakka Culture in Mei Nong and environmental resource in the area.

Taipei Hakka World Society. "Purpose of Water Resource Agency" Taiwan Times. 9 May 1999. 4 Jul. 2004 <<http://mpa.ngo.org.tw/why-no-dam/relation/990509.htm>>

Lee, C. C. "Breaking the monopoly of dam from Chi Yong Lake meeting in 13 Sep. 2004" Coolloud. 17 Sep. 2004. 8 Oct. 2004

<<http://61.222.52.195/news/Database/Interface/Detailreview-print.asp?ID=100801>>

Figure one Production process



The Design phases normally take place years before the actual mass manufacturing of the chips, and it was done on the computer, and during this phase a master circuit pattern called mask is create, it will than be put on to the silicon wafer (Mazurek, 50).

A pure silicon cylinder is call silicon ingot, which are slice and polish into wafers, and than the surface is smooth with Chemical Etching Process in order to remove impurities (Bates). As the name implied, there are chemicals involved in this process, which make it likely to cause hazardous industrial waste. Fabrication phase is relatively chemical intensive and it takes place in the clean rooms, the reason for this is that even bits of dust can damage circuitry of memory chips (Bates). Clean rooms rank from 1 to 10, there is about one particle of dust in a cubic foot of air in the clean room 1, and it use a lot of energy because the air had to be continuously filtered and

circulated. And while in the clean rooms, worker had to put on protective clothing to keep the air particle free not to protect them from chemical exposure, therefore the workers who work in the clean room were been expose to the toxic chemicals (Mazurek, 49). Fabrication process means that some part of silicon wafer goes through process such as Photolithography, and others are etching by chemicals and water. As can be seen from Figure one, there are four steps within fabrication phase, which are:

Exposure: Silicon wafer is covered with a layer of glass followed by nitride layer, and than exposing to the oxygen, after heating the oxidation process started. In this process the waste such as organic solvent vapors, spent solvents and water that wash organic solvents away from wafer was generated (Mazurek, 51). Photolithography take place after the oxidation, in which wafer was coated with photoresist and process design is beamed onto the wafer (Bates), the circuitry pattern is defined. U.S. EPA had compose a table of the chemicals used in the photolithography process, as can be see in the Table One and some of the chemical are know to cause cancer in human.

Table One chemicals used in the production process

Photoresists	Developers	Solvents & cleaning agent
Ortho-dizaoketone	Sodium hydroxide	Deionized water

Polymethacrylate	Potassium hydroxide	Detergent
Polyfluoroalkylmethacrylate	Silicates	Isopropyl alcohol
Polyalkylaldehyde	Ethylene glycol	Acetone
Polymethylemethacrylate	Isopropyl alcohol	Ethanol
Poly(hexafluorobutylmethacrylate)	Phosphates	Ammonium hydroxide
Isoprene	Ethyl acetate	Xylene
Ethyl acrylate	Methyl isobuty ketone	Ethylbenzene
Copolymer-ethylacrylate	Xylene	Chlorotoluene
	N-Buty acetate	
	Cellosolve acetate	
	Isopropyl alcohol	
	Glycol ethers	

U.S. EPA 1995b.

Pattern definition: The unwanted material is etched from the wafer, and chemical is used to clean away harden photoresist. There are number of methods with which this is done, for example wet etching using acid solution, dry etching using gas, plasma etching etc. Most often used method is the dry etching, which provides better resolution of the lines (Mazurek, 52).

Cleaning and Diffusion: The electrically charged particles are doped into the silicon to form semiconductor regions, the energized dopants such as Boron, Arsenic and Phosphorous in shapes of specific impurities are implanted into areas not protected by layers. Then the photoresist is removed with chemical and plasma baths, and silicon wafer is expose to vapors of dopant at high pressure (Bates).

Metallization: The metal wires are used to connect the electrically active regions on the chips, and Photolithography fuses the electrically active component. This step creates hazardous wastes such as acid fumes, organic solvent vapors, liquid organic waste, and liquid cleaning solutions (Mazurek, 52).

As the semiconductor chips consist of layers upon layers of transistor and circuitry, the above steps are performed repeatedly, until desire function are implanted into the chips (Bates).

The production volume of Taiwan semiconductor is the largest in the world, so the use of chemical is great as well. While the Taiwan's semiconductor has now catch up with the industrial giant like Intel etc. as production of new chips are experience here, we are experience the chemicals first handed. The individual chemical is bad enough, as semiconductor products cycle is fairly short²¹, the effect of the chemicals used before

²¹ Moore's Law which states that as semiconductor industry focus on continuous innovation, the power of computer chips would double every 18-24 months.

production can not be properly studied, and it is very difficult to get the hazardous industrial waste those chemical became after the production proper treatment in Taiwan since cost of proper treatment high and laws regarding environmental safety are not strict.

The following are some of the chemicals used in the semiconductor production that have possible dangerous effect on human:

1. Xylene: Used in electronic circuit boards, to prevent circuit faults caused by humidity and condensation. It is also used in coating on aluminum heat exchanger to improve durability²². Long-term exposure to this chemical can cause headaches, irritability, depression, insomnia, agitation, extreme tiredness, tremors, impaired concentration and short-term memories. Xylene could cause liver and kidney damages and miscarriages²³.
2. Ethylbenzene: It is used as solvent and diluents in the production. It is another form of Xylene, the health effects of Ethylbenzene is similar to that of Xylene²⁴
3. Benzene: It is used as solvent in the semiconductor production, and has been on the reduction usage list of countries like Japan, U.S. etc. Long-term exposure to Benzene could result in aplastic anemia or leukemia, and the International Agency

²² *Managing and reducing substance with environmental impact*. Denso Corporation. 8 Jul. 2004
<<http://www.denso.co.jp/ENVIRONMENT/e-report/2003/33.html>>

²³ *Health effects of Xylene*. Canadian Center for occupational health and safety. 8 Jul. 2004
<http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/xylene/health_xyl.html>

²⁴ *Health effects of Xylene*. Canadian Center for occupational health and safety. 8 Jul. 2004
<http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/xylene/health_xyl.html>

for Research on Cancer (IARC) has concluded that there is sufficient evidence for carcinogenicity to humans. Benzene could cause cancer of the lymph system²⁵ (lymphoma), lung cancer and bladder (urothelial) cancer.

4. Styrene: It is used as insulator, resins and main binder for toner used in copier, laser beam etc²⁶. It is possible for male workers who had been exposed to the Styrene to increase percentage of abnormal sperm head shapes and the female fabrication workers showed an increased risk of miscarriages²⁷.
5. Lead: International Agency for Research on Cancer classified it as possible cause of human carcinogen. It could affect central nerve system, digestive system, blood and heart.²⁸
6. Acetone: Female workers, whom work in the fabrication section of the production, have higher rate of miscarriage, which could possibly cause by the Acetone²⁹.

It is very difficult to actually prove to whom those chemicals belong to since there is no proper monitoring system for the hazardous industrial waste by government.

Monitoring the hazardous industrial waste is made difficult by:

1. Asymmetric information between producers and the government officials.

²⁵ *Health effects of Benzene*. Canadian Center for occupational health and safety. 8 Jul. 2004
< http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/xylene/health_xyl.html>

²⁶ *Functional chemicals and engineered materials business group*. Business & Products. 9 Jul.2004
< <http://www.mitsui-chem.co.jp/e/bp/index.htm>>

²⁷ *Health effects of Aceton*. Canadian Center for occupational health and safety. 9 Jul. 2004
< http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/xylene/health_xyl.html>

²⁸ *Health effects of Lead*. Canadian Center for occupational health and safety. 8 Jul. 2004
<http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/lead/health_lead.html>

²⁹ Refer to reference 27.

Producer lack incentive and willingness to co-operate with government official when collecting the data.

2. Lack of the industrial knowledge by bureaucrats. The loophole of waste treatment process and transportation is in waste reporting, register and data, different department within the institution cannot co-ordinate and co-operate.
3. Lack of transparency.
4. Lack of monitoring. This is most obvious the cause of the Sheng Li and Eternal Chemical case, 412 firms contracted their waste to be handled by Sheng Li instead of the 87 reported by Sheng Li, and EPA did not pick up on this fact until after the pollution incidents, at same time all of Sheng Li's customers was ignored of this fact seems unlikely since some of the customers were cluster in certain areas like Hsinchu Science Industrial park or Kaohsiung industrial Zone. EPA had been grossly negligent in not notice this fact.
5. The reporting of the amount of hazardous waste depended on the moral of the producers.

There is no final treatment facility; therefore EPA could not effectively monitor and control amount and types of waste. Firms tend to be profit oriented therefore outsourcing the waste treatment to other firms.

One of the negative externality of the industrialization is the environmental pollution, and the semiconductor production is no exception. The problems caused by the high tech production are the following:

1. Waste disposal: The waste here means industrial waste and hazardous industrial waste. The problems here is the storage and treatment of such waste, often developing nations are not equip or have the ability to deal with the waste generated by the semiconductor productions. Government lack the information and knowledge in treating contamination, at same time the monitoring of the environment performance of the firm are a big challenge for the government.
2. Water pollution: Pollution included the ground water pollution and contamination of the rivers, irrigation canal. The ground water pollution most likely to occur when firms pour chemicals into the well within the production site. And the causes of river contamination are illegal discharge of wastewater and solvent by semiconductor firms or the waste treatment firms. The water pollution could easy lead to the soil pollution and ground water contamination. Because of the structure of the Science Industrial Park, it is very difficult to find the culprit in Hsinchu. At present, the test for pollution does not suit the semiconductor industry, since the test cannot measure the contamination by the chemical substance, which is used in the semiconductor production.

3. Air pollution: During the semiconductor production gases are used to gain chemical reaction, as chips are heated it releases toxic fumes, and workers would inhale the fumes because they often work without necessary protection. Due to lack of space in Taiwan, Science Industrial Park and local residence live side by side. Communities nearby would be affect by the fumes from the production facility and the fumes release by the waste treatment facility. Therefore air pollution is another deadly threat to the communities.

The type of pollution in Hsinchu Science Industrial Park are more than mention here, the below analysis would focus on the waste disposal and water pollution, as those are the ones that cause serious trouble in the Hsinchu area.

3.3 Case Study

3.3.1 Water pollution

The water pollution has wide spin-off effect on the environment, since it can lead to other types of pollution, especially the soil contamination. The water pollutions in and around the Hsinchu Science Industrial Park are very serious, since the lack of treatment facility means most of the wastewater was discharged into the sewage

system or nearby rivers.

Before looking at pollution in the Hsinchu Science Industrial Area, certain understand of the test for pollution is necessary. Table Two below is the standard for pollution; degree of pollution is slight pollution, light pollution, medium pollution and serious pollution. The following were being tested:

Dissolve Oxygen (DO): Which is the oxygen that has been dissolved into water, less polluted water has higher mg/L, temperature of the water is lower vice versa³⁰.

Biochemical Oxygen Demand (BOD): Under certain time and temperature, the oxygen needed by microbes when organic substance become oxidize³¹.

Suspended Solid: The amount of solid particles in the wastewater or other liquid after been filter.

Ammonia Nitrogen: This is result of living being that interact with the nitrogen compound within the water. Which could affect the taste of water, and is one of the important indicators of the quality of water.

Table Two Pollution degree of the river

項目	Degree of pollution	Slight Pollution	Light Pollution	Medium Pollution	Serious Pollution
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³⁰ DO. Tai Chung EPA. 12 Oct. 2004 <http://www.tcepb.gov.tw/index/knowledge/kno1_02.asp?id=83>

³¹ BOD. Tai Chung EPA. 12 Oct. 2004 <http://www.tcepb.gov.tw/index/knowledge/kno1_02.asp?id=84>

溶氧量 (DO) mg/L	Above 6.5	4.6-6.5	2.0-4.5	Under 2.0
生化需氧量(BOD ₅) mg/L	Under 3.0	3.0-49	5.0-15	Above 15
懸浮固體 (SS) mg/L	Under 20	20-49	50-100	Above 100
氨氮 (NH ₃ -N) mg/L	Under 0.50	0.50-0.99	1.0-3.0	Above 3.0
Points	1	3	6	10
Average	2.0 以下	2.0-3.0	3.1-6.0	6.0 以上

Note:

1. The numbers in the table represent average value.
2. The average for DO、BOD₅、SS、NH₃-N was taken.
3. Information source: Provincial Environmental Protection Agency. The Yearbook of quality of the Taiwan River, Volume 23: 1998.

The Table Two is the pollution along the Ke Yea River, as can be see from the tests done, it was heavily polluted

Table Three Ke Yea River pollution in 1999

Sample position	DO (mg/L)	BOD ₅ (mg/L)	SS (mg/L)	NH ₃ -N (mg/L)	Average	Degree of Pollution
Ching TsaoLake	6.1	7.4	72	1.9	5.25	Medium pollution

(青草湖)						
Ke Yea River Bridge (客雅溪 橋)	5.1	10.2	75.3	12.5	6.25	Serious pollution
Shiang Yea Bridge (香雅橋)	4.1	18.4	96.8	14.4	8	Serious pollution

Data Source:

1. Environmental Protection Agency water quality data base. › http://alphapc.epa.gov.tw/cgi-bin/get_river-fixed? › October 2001
2. Zhong Ding Company, October 2001.

The Table Four and Table Five are the pollution along the lower stream of the Ke Yea River in 1999; the pollution is severe near the Hsinchu Science Industrial Park.

Table Four Ke Yea River pollution in the first and second quarter of 1999

Sample position	DO (mg/L)	BOD ₅ (mg/L)	SS (mg/L)	NH ₃ -N (mg/L)	Average	Degree of pollution
Zhong Xing Bridge (中興橋)	5.8	11	224	2.9	6.25	Serious pollution

Science Industrial Park (2) downstream (科 學園區 (2) 下 游)	6.4	8.5	13.5	15.9	5	Medium pollution
Science Industrial Park (1) downstream (科 學園區 (1) 下 游)	4.4	29.7	189	16.2	8.25	Serious pollution
Peace Bridge (和 平橋)	4.3	21.5	268	12.7	9	Serious pollution
Shiang Yea Bridge 香雅橋	3.0	8.7	125	11.8	8	Serious pollution

Data Source:

1. Web site of Hsinchu Environmental Protection Agency, <http://www.hccep.gov.tw/>, October 2001.
2. Zhong Ding Company, October 2001.

Table Five Ke Yea River pollution in 2001

Sample Position	DO (mg/L)	BOD ₅ (mg/L)	SS (mg/L)	NH ₃ -N (mg/L)	Average	Degree of pollution
Dang Xian Bridge (當賢橋)	5.1	10.5	295	15.34	7.25	Serious pollution
Downstream of Pipe line (排放口 下游)	4.6	10.5	108	5.67	7.25	Serious pollution
Zhong Shan Bridge (中山橋)	5.1	8.5	131	22.7	7.25	Serious pollution

The Table Six and Seven are the pollution in the Tou Chyan River, which showed that there is only slight pollution.

Table Six Tou Chyan River pollution in the first and second quarter of 1999

Sample position	DO (mg/L)	BOD ₅ (mg/L)	SS (mg/L)	NH ₃ -N (mg/L)	Average	Degree of pollution
Tou Chyan River Bridge (頭前溪 橋)	9.0	ND-2.4	21.7	ND-0.08	1.5	Slight pollution

Shi Zhou Bridge(溪洲橋)	8.0	ND-2.3	31.1	ND-0.12	1.5	Slight pollution
Old harbor Bridge(舊港大 橋)	7.6	ND-5.3	33.5	0.78	2~3.25	Medium pollution

Note:

1. The number represent average value.
2. The average for DO、BOD₅、SS、NH₃-N was taken.

Information source:

1. Web site of Hsinchu Environmental Protection Agency, <http://www.hccep.gov.tw/> , October, 2001.
2. Zhong Ding Company, October 2001

Table Seven Tou Chyan River pollution in 2001

Sample Position	DO (mg/L)	BOD ₅ (mg/L)	SS (mg/L)	NH ₃ -N (mg/L)	Average	Degree of pollution
Great Bridge of Zhu Ling (竹林大 橋)	8.5	1.4	18.2	0.13	1	Slight pollution

Great Bridge of Zhong Zheng (中 正大橋)	8.1	1.1	14.9	0.24	1	Slight pollution
Tou Chyan River Bridge (頭前溪 橋)	8.1	1.4	24.4	0.26	1.5	Slight pollution
Shi Zhou Bridge(溪洲大 橋)	8.0	1.2	20.6	0.08	1.5	Slight pollution

Note:

1. The number represent average value.
2. The average for DO、BOD₅、SS、NH₃-N was taken.

Information source:

1. Environmental Protection Agency water quality database, http://alphapc.epa.gov.tw/cgi-bin/get_river-fixed?, October 2001.
2. Zhong Ding Company, October, 2001.

The production of the semiconductors is relatively water and energy intensive, most of the input use in the production does not included in the final product, and therefore during the production large amount of wasted water was produced. The water is an

irreplaceable input in the production of the semiconductor, as Taiwan is a country with limited water resource; industries have to compete for rights to use water. In the quest for water, environmental factors had been put aside in the decision making, as pressure is on government to produce reliable water source, the often blunt disregard for natural environments would be the cause for future environmental disaster.

As can be seen from the Table Five in the Chapter 2, the Hsinchu Science Industrial Park has serious waste water problems, most cases were cause by the illegal discharge of the waste water by the firms within the park, and as park is industrial cluster, it is impossible to determine the identity of the culprit. As polluter could not be identified, this has serious implication in the enforcement of the law, and trustworthiness of the legal system. Another disadvantage of the industry cluster the size of Hsinchu Science Industrial Park is that individually, waste produce by each firm were within the limit set by the management of the park, however the total amount of the waste water produced by the park has exceeded legal standard.

It was to be believed that in the 80s the treatment of the waste water produced by the park was inadequate, as people became more environmental conscious, more effort was put into prevention of pollution, but it is tough for business to adjust to the new standard, not to mention costly.

Government had made it clearly that the industry would have the priority to the use of water. In 2002, there was a minor draught in Taiwan, the insufficient of water cause fight for water, both industry and agriculture refused to compromise, situation reach a stand off. Industry argued that, it was obvious that the opportunity cost of water used in agriculture was too great since when that same amount of water used in industrial production (for example semiconductor) could yield greater return. Government taken side of the industry added that because of Taiwan's entry into WTO, the agricultural production would decrease at increasing rate; they would no longer need much water in the long run³². They promised that the lost suffered by the agricultural sector due to the shortage of water would be compensated by government. While this move benefit industrial producer, and lost suffered by farmers were reduced, but tax payers bears the environmental and compensation costs, in the end the producer came out winner on all round. At that time the Director General Lee of Hsinchu Science Industrial Park negotiated with the Director General Huang of Hsinchu Irrigation Association (新竹農田水利會), and it was agreed that 15 thousand hectare of farmland would not carried on with farming (this decision mean that NTD 7 billion in compensation had to be pay to the farmers), and Hsinchu Irrigation Association would provided 50

³² "Prim Minister: Industry has right to water." *China Times*. 6 Jun. 2002. 20 Jul. 2004
< <http://e-info.org.tw/2002/06/0606/020606.htm>>

thousand tons of water to park every day until the situation improve³³. Another deal between Hsinchu Irrigation Association and Science Industrial Park was that the park could discharge wastewater into the reservoirs and irrigation channels³⁴. The representatives of villages in Shiang Shan (香山) District accused irrigation association to be the culprit behind the metal contamination of 30 hectare of rice field in the Shiang Shan Hsinchu City, and they believe that Director General Huang had betray the farmers by allowing the waste water from the Hsinchu Science Industrial Park to enter into the irrigation channels. This had started a fight between the Hsinchu Irrigation Association and EPA, the Director General Huang said that the firms in the park were allow to discharge water into the irrigation channels for the development of Taiwan economic and since 2001 waste water was discharged into irrigation channels for a fee, but later he change his story by saying that the firms were never allow to discharge waste water into irrigation channels. However, EPA said that they would not allow wasted water to enter into the irrigation channels without approval by the Irrigation Association. As departments refused to be responsible for the contamination of the farmland, and Hsinchu Science Industrial Park is a large firm clusters, it is impossible to find the polluter, and nothing come out of this investigation, people

³³ Wen, S. M. "1.8 thousand hectare agricultural land wasted" *Central Times*. 28 Feb. 2002. 20 Jul. 2004

< <http://www.cdn.com.tw/daily/2002/02/28/text/910228d4.htm>>

³⁴ Chang, C. S. "Who is responsible for the stink of irrigation canal?" *China Times*. 31 May 2003. 20 Jul. 2004 <http://homepage.ntu.edu.tw/~d91544007/NEWS/news_tw.htm>

quickly lost interest in the case.

The wastewater treatment and discharge has always been a serious problem in Hsinchu, up to 1997 Hsinchu Science Industrial Park still do not have proper management of wastewater³⁵. In the 1997, the park was accused of discharging waste water into the nearby rivers such as Ke Zi Hu River (柯子湖溪), Long En Irrigation Canal (隆恩圳) and Ke Yea River (客雅溪) etc. It was obvious that since the establishment of the park, the only treatment for waste water was to release it into the nearby river, this had cause a shock among government officials as well as the public, the park officials could not provided information regarding the amount of waste water released, where was it released, and state of treatment when released³⁶, since the equipment for monitoring the comings and goings of waste water was never in operation. This has serious implication in the contaminations of rivers, since the untreated industrial waste water was discharged into Long En Irrigation Canal, first it will polluted soil of the farmland along the bank of Long En Irrigation Canal, and as this river is also used for irrigation, the industrial waste water enter into the irrigation channels which cause further contamination of the agriculture products of the area.

³⁵ Chang, C. S. "Hsinchu Industrial Park waste water treatment facility has no discharge data." *China Times*. 31 Oct. 1997. 21 Jul 2004

< http://www.gcaa.org.tw/env_news/199710/86103101.htm>

³⁶ Chang, C. S. "Water Society was responsible for the stink of En Long Irrigation Canal." *China Times*. 31 May 2003. 21 Jul. 2004 <http://homepage.ntu.edu.tw/~d91544007/NEWS/news_tw.htm>

Second as Long En Irrigation Canal is connected to the Tou Chyan River (頭前溪), and Tap water company has stations at down stream of Tou Chyan River, to provide tap water to the Hsinchu residence. Therefore if Long En Irrigation Canal had been contaminated than the quality of drinking water at Hsinchu would be compromise.

The Long En Irrigation Canal had been an ancient irrigation channel, in it there were species of fishes which could only be found in Taiwan, therefore every time the toxic industrial waste water polluted Long En Irrigation Canal, many valuable fish species were killed, which in terms will affect the whole ecology system. Right now this river is use for agricultural, industrial and household purpose, and under the existing Water Act there is no regulation that required environmental assessment or duty to protected living species in the river³⁷. This incidents had expose gross negligent of management of Hsinchu Science Industrial Park, as it turn out the contamination of river is not the only problem in the park, apparently some of the firms within the park had been digging wells within their facility which could lead to pollution of underground water. With establishment of the Hsinchu Science Industrial Park Environmental Monitoring Team (新竹科學工業園區環保小組) by National Science Council (行政院國家科學委員會) in 2000, the situation with waste water emission had improve some what, however because of the surveillance, firms within the park adapted a different

³⁷ "Fish committed suicide in Tou Chyan and En Long" *River Condition*. 11 Jul. 2000. 20 Jul. 2004 <<http://contest.ks.edu.tw/~river/environment/recognize/recognize17.htm>>

approach to release waste water, and that is through sewerage system³⁸. As can be seen from table five in the chapter 2, the nearby community and villages suffered from the pollution in the sewage system, especially the Presbyterian Bible College (聖經書院) and Franciscan Nunnery (修女院) had been severely affected, in the epidemiology study on the near by residence as well as teacher and student of the Presbyterian Bible College, shows that 56% has blood abnormality, 26 people have liver function failure, and 37 people have kidney problems, although this report had proof that there is problems, but nothing further had been done on it. The test conducted by EPA shows that Acetone³⁹ and Isopropyl Alcohol⁴⁰ found in the waste water monitoring point near Presbyterian Bible College were 7 times higher than norm, at same time concentrated Hydrofluoric Acid⁴¹ was found as well⁴². Although those dangerous substances were found in the industrial wasted water, but EPA did not list those under the control substances, as high tech industries were different from other industries, inputs into the production are different as well. High tech industries use many toxic

³⁸ Huang, T. U. 2001 Report of Hsinchu Science Industrial Park Environmental Monitoring Team. 20 Jun. 2003

< <http://www.hsinchu.org.tw/2000rpt.html> >

³⁹ Acetone is a flammable solvent used primarily to clean-up positive photoresist, it moves quickly between soil, water and air. If it enter into human body, it could cause skin damage, unconsciousness, headaches; light-headedness; confusion; increased pulse rate; effects on blood; nausea; vomiting; unconsciousness and possibly coma; and shortening of the menstrual cycle in women. As of now, there was not enough study done to indict this substance can cause cancer.

⁴⁰ Isopropyl Alcohol is highly volatile organic solvent used in wafer drying. It can cause central nervous system depression irritation of the eyes, nose, throat respiratory distress, stupor, coma, and paranasal sinus cancer. It was know to be carcinogenicity.

⁴¹ Hydrofluoric Acid is use to remove surface oxides from Silicon in the semiconductor industries. Hydrofluoric acid exposure can result in severe or even lethal damage to the heart, liver, kidneys, and nerves.

⁴²“Shan San poison oyster is recorder of the industrial development in Hsinchu area.” Online posting. 12 Jan. 2001. Coolloud. 20 Jul. 2004 < http://61.222.52.195/information/review/2001_01_12_02.html >

substance in the production, their production waste are highly toxic as well, as individual chemical is dangerous on it's own, when mix it's effect is dangerous as well as unpredictable, therefore it need environmental regulations specially create to regulate high tech industries. As the existing regulations were not design to regulated high tech production, the high tech industries had release poisonous and deadly chemicals into the environment, this serious problem had to be deal with as soon as possible.

It is obvious from Table Two to Five that the Ke Yea River had been serious contaminated, as it contained high concentration of regulated substance. Relatively Tou Chyan River are better off than the Ke Yea River, in terms of the 36 substances regulated by EPA because Tou Chyan River is in the water source protection zone.

Since 2000, there seems to be at least one major river pollution every year in Hsinchu area, and each of those pollutions not only endangers the species in their natural environment but also the human. The wastewater that was released into the Ke Yea and Long En Irrigation Canal is so toxic that the fish in the river would turn up dead over night, the body of dead fish could be seen for miles, and it has become the usual occurrence in that area. Especially in May and June of 2001, industrial waste water was discharged into the rivers that was used for irrigation and drinking, although the government had promised to deal severely with the perpetrator of this crime, but

specific perpetrator was never found, so it become difficult in hand out punishment for the whole park. In the autopsy done on the fishes killed by the pollution of the Long En Irrigation Canal in May showed that there were high concentrations of titanium, copper, tin, tungsten, and indium in the dead fishes, at least 13 times higher than the normal fish. Which means Long En Irrigation Canal contained high concentrations of those metal, and so the waste water that contain those metals should come from the semiconductor plant, since those metal were frequently used in the production plant of semiconductor, LCD, IC board⁴³. The water contamination of Long En Irrigation Canal in May had devastating impact on ecology, the toxic waste water killed around 20 000 fishes, and as Long En were polluted so is the farmland on it's bank, further more the local residence at that time had relied heavily on the ground water, it would no doubt affected by the toxic chemicals release into the ecology.

Although the test done by Zhong Ding Company in the Table Six and Table Seven show that the Tou Chyan River are only slightly contaminated, but with the rate the Long En river had suffer from contamination, it seems unlikely that the Tou Chyan River could remain unaffected⁴⁴. On average the rivers were been polluted 2-3 times a year, a study done in 2001 by the Professor Ling Yong Jian (凌永建) of Ching

⁴³ Ling, Yong Jian et al. "Report of the investigation on the Long En dead fish." Hsinchu Foundation. 6 Jul. 2001. 21 Jul. 2004 <<http://www.hsinchu.org.tw/20010706.html>>

⁴⁴ "Long En dead fish cry for justice." *Union Times*. 15 May 2001. 21 Jul. 2004 <<http://www.hsinchu.org.tw/20010517.html>>

Hwa University show that the Taiwan oyster is 500 times as poisonous as the oyster of America. All factors of above show the seriousness of the water and river pollution in Taiwan.

However as the pollution become undeniable, government is still very much behind with the information regarding the environment pollution. In 2000 and 2001, Macronix (旺宏) International Co., Ltd and Tyntek Corporation (鼎元光電) had polluted Ke Yea River⁴⁵, both companies are large corporations, Macronix is a semiconductor design and manufacturing firm with asset value of NTD 335 billions, Tyntek Corporation is also a semiconductor manufacturing firm with asset value of NTD 20 billions. Both company claims to be environmental conscious, in the mission statement of companies, environmental care of companies were mentioned, Macronix followed ESH policies⁴⁶, while Tyntek “Operate in an environmental friendly manner

⁴⁵ 2001 reports of Hsinchu Science Industrial Park Environmental Monitoring Team.

⁴⁶ ESH policy is specified as follows:

1. Rights and Obligations: Provide employees a comfortable, safe and healthy environment and make the best efforts to fulfill the duties and obligations regarding the ESH.
2. Regulation Obedience: Abide by the ESH regulations and thoroughly carry out the ESH works.
3. Hazard Prevention: Prevent pollution and damages by hazard identification, risk assessment, environmental impact analysis and hazard source control.
4. Education and Training: Provide employees with superior and complete ESH education and training programs for assuring them to be able to appropriately implement the ESH works accordingly.
5. Sustainable Development: Ensure long-term development of ESH works by effectively utilizing the corporate resources based on OHSAS 18001 (Occupational Health & Safety Assessment Series) and ISO 14001 (Environmental Management System).

because protecting the environment is every corporations' responsibility.” In 2000, Macronix had discharge industrial waste water into the Ke Yea River, as river were used for irrigation for the farmland along its bank, this had threaten the health of the local residence. At same time, large quantity of fish had turn up dead again, this is also the first case in which a specific firm was hold responsible for the water pollution⁴⁷. The information concern this case had not been made public, in fact there is not much information to be found, we have no information regarding circumstances of this incidents, what and how it happened? What were the causes of this pollution? Which chemicals Macronix used? What is the reaction of the firm and EPA? And what was the punishment for Macronix? All of which were unknown to the public, the information were not transparent, which could create loopholes for the firms that cause the pollution. Although this case is shrouded under a veil of secrecy, there do not seem to be any press report on the case, same as the Tyntek case, the only mention of the cases seem to be in the report of the Hsinchu Science Industrial Park Environmental Monitoring Team or the essays by the active environmentalist. There is even less mention of the pollution cause by the Tyntek, this seem to indict that there is lack of concern for the environmental condition and workplace safety especially within the Hsinchu Science Industrial Park. With weak labor movement in Taiwan,

⁴⁷ Ka, C. B. “Dead fish of Ke Yea River.” *News*. 23 May 2001. 22 Jul. 2004
<<http://www.hsinchu.org.tw/news.html>>

workplace safety is not much concern of the Capitalist, but somehow the workers were not much concern either, it could be that in Hsinchu Science Industrial Park the distinction between workers and shareholders of the company, since most of the workers in the park were entitle to shares as bonus. Therefore workers tend to make less demand that were normally seem as causing harm to the company welfare, in the study done by Dermatology department of National Cheng Kung University Hospital (成大醫院) show that the Taiwan semiconductor workers were 200 times more likely to develop occupational skin disease than the California semiconductor workers⁴⁸.

3.3.2 Waste Disposal

From Table Five in chapter two, it is clear that the public nuisance occurs within and around Hsinchu Science Industrial Park, it seen that most serious problems were the water and air pollution, those problems were easy notice by the local residences. As all types of pollution will ultimately lead to others, for example the waste disposal could lead to water and soil contamination, and water pollution could lead to soil contamination. Right now the most difficult to control pollution are the disposal of

⁴⁸ China Times. 2 Feb. 1998. 23 Jul. 2004
<<http://www.bamboo.hc.edu.tw/workshop/session10/visit/wastewater/coolloud.html>>

hazardous industrial waste and water pollution, because once they were notice it is often too late to do anything to remedy the past action unless great deal of resources were spend over long period. In the semiconductor production, most of the input used in production was not consisted in the final product, therefore there is tremendous amount of the industrial waste (which are often hazardous) to be treated and disposed of. An estimate of 23 million tons of industrial waste was produced in Taiwan every year, and out of which 2.5 to 3 million is the hazardous industrial waste, however only one million 60 thousand ton of the hazardous waste was registered. Right now there are 30 Premier Industrial Waste Treatment Organizations⁴⁹ and they are able to treat 820 thousand tons of waste per year. There are 12 Secondary Industrial Waste Treatment Organizations⁵⁰, with capacity to treat 60 thousand tons of waste per year. In another word, only 880 thousand tons of hazardous industrial waste will be treated, which is only half the amount estimated by Industrial Technology Research Institute, it is clear that at least 80 thousand tons of hazardous waste went untreated. In the

⁴⁹ “Describing problems: Management of the Industrial waste.” Peng Hu County. 5 Jul. 2004
< <http://www.phhg.gov.tw/chinese/service/faq/19-34.htm> >

Premier Industrial Waste Treatment Organization is able to treat general waste, industrial waste, and hazardous industrial waste, and have to fulfill the following requirements:

1. The real capital is above NTD 150 million.
2. Have to employed 4-second level technicians and 2 first level technicians.

⁵⁰ “Describing problems: Management of the Industrial waste.” Peng Hu County. 5 Jul. 2004
< <http://www.phhg.gov.tw/chinese/service/faq/19-34.htm> >

Secondary Industrial Waste treatment Organization is able to treat general waste, industrial waste, and hazardous industrial waste, and have to fulfill the following requirements:

1. Organization that was established for the purpose of treatment of it’s own waste, but they do have excess capacity with which to treat waste of other producers.
2. Employed a second level technician and if treating hazardous industrial waste than one first level technician is necessary.

research done by Industrial Technology Research Institute, the statistic show that only 40 thousand tons of hazardous waste was properly treated every year, and 120 thousand tons waiting to be treated. As storing and treatment of those hazardous waste were expensive, through loophole in legislatures firms were able to dump those hazardous waste elsewhere, this lead to the problem of unauthorized disposal sites through out Taiwan. To be fair the hazardous waste created by manufacturing sector is just part of the Taiwan's problem with waste, as Military do not have waste treatment facility of their own, and under Basel Convention commission overseas firm for disposal of the waste is not possible, therefore the total waste accumulated in Taiwan is staggering, and Taiwan lack ability, willingness and resources to deal with this problem⁵¹.

Table Eight The amount of waste produce by the manufacturing sector and non-manufacturing sector

行業別	總量（公斤／日）	有害比例	有害廢棄物（公斤／日）
食品業	9,525,245	0.14%	13,355
金屬基本工業	9,338,906	4.79%	447,334

⁵¹ Wu, I. S. "Threat of hazardous substance on the sustainable growth." *National Policy Foundation*. Jan. 2004. 6 Jul. 2004 <<http://www.npf.org.tw/monthly/0401/theme-240.htm>>

化學材料業	1,815,034	24.98%	453,395
金屬製品業	1,678,304	20.93%	351,269
木材及傢俱業	1,476,617	0.12%	1,772
非金屬礦物業	1,395,721	0.12%	1,675
電力及電子業	1,334,201	15.71%	202,398
造紙及印刷業	1,160,546	0.69%	8,008
塑膠製造業	978,994	0.27%	2,643
機械設備製造業	814,898	6.65%	54,191
運輸製造業	751,882	0.91%	74,512
紡織業	719,920	0.41%	2,952
橡膠製造業	375,493	0.01%	38
飲料煙草業	241,857	0.00%	0
皮革毛料業	189,882	28.73%	54,553
化學製品業	147,952	10.68%	15,801
成衣服飾業	46,655	0.21%	98
精密機械製造業	36,941	9.38%	3,465
石油及煤製造業	7,157	19.31%	1,382
雜項工業	591,752	0.57%	3,373

非製造業	34,418	7.13%	595
總計	32,662,176	5.18%	1,691,901

From: 經濟部工業局 87 年調查資料

As can be seen from Table Eight, in 1999 the 15.71% of the waste generated by semiconductor production was the hazardous waste, which was after the relatively more traditional industries like metal and chemical and was know for their ability to cause pollution. The semiconductor industry, which was known for their high efficiency production and green imagine, was causing 202,398 Kg of hazardous industrial waste per day. However by 1999 the export value of the semiconductor industry is only 52% by the end of the 2003 the export value had reached 62%, which is ten percent increase, it is clear that the production had increase in those 4 four years, with it the hazardous waste. Another factor is that by the year 2001 Taiwan had started to catch up with the large foreign firms and are producing front of the line products, which means we are experimenting with the chemicals first hand, this could lead to the increase in the hazardous waste create during the production process.

Table Nine Cases of public nuisance in Hsinchu area⁵²

⁵² ROC. Environmental Protection Agency. *White Paper of Public Nuisance 2 002 Executive Yuan EPA*. Taipei: ROC, 2002.

Year	Air Pollution 空氣污染	Miasma 惡臭	Noise 噪音	Waste 廢棄物	Water pollution 水污染
1994	525	404	656	4104	242
1995	498	538	540	1568	241
1997	491	409	559	2268	234
1998	497	456	487	2216	234
1999	460	557	503	2406	267
2000	411	645	573	1588	280
2001	555	726	623	1120	458
2002	1358	674	-	1751	322

Note: - denote data unknown.

In Table Nine it is obvious that the reporting of the public nuisance waste dumping cases fluctuated wildly, over the years local residence of Hsinchu listed the dumping of waste as the largest environmental problem. The largest fluctuation of the waste dumping report was between 1994 and 1995, the reported cases fall by half from 4104 to 1568, and after 1995 the cases reported was under 3000 cases, under 2000 after 1999. What had caused this decrease in the cases reported? There are several possibilities:

1. People lost faith in the Bureau of Environmental Protection of Hsinchu area. If reporting cases do not get result, people would stop reporting.
2. The waste dumping was shifted to other locations.
3. The dumping had decrease.
4. The waste was collected in specific sites.

The worst-case scenario is the possibility number one, in which citizen had lost trust in the state and likely to make situation worst by further unlawful behavior⁵³. In situation like this strong government action is needed to reinforce the law, and harsh punishment might be necessary. The Best situation is the possibility number three, however it is also the most impossible case, because in Taiwan the market mechanism necessary to make this happen is lacking due to the insufficient infrastructure facilities, which make treatment of waste expensive. At same time the lack of incentive also make it hard for firms to reduce industrial waste. With constant production capacity of semiconductor increases, it does not see likely that industrial waste would decrease.

Right now EPA had scientific investigation done on two waste dumping sites Chan Yi Xiang (陳宜香) and Ye Bu Xiong (葉步雄) in Hsinchu area, and the evidences had show that both sites had been contaminate by Volatile Organic Compound (VOC).

The story was similar in both sites, owners had not applied for the change in land

⁵³ Francis Fukuyama, *Trust: The Social Virtues and the Creation of Prosperity*, New York: Free Press, 1995.

usage, soil was removed from the sites in 1997, so the industrial waste was dumped into the hole made by the removal of the soil. Once the waste was dumped, a layer of soil was added to cover up the waste, excess water was extracted by the water pump and dumped into the nearby lake or ditch. Which had severely contaminated the nearby agricultural land and natural environment, therefore Hsinchu city government had banned the further dumping of the industrial waste and the owner of the land was given fines for the violation of the law. But the situation did not improve, dumping was still carried on, causing the contaminations to spread further, in the end local authority strongly reinforced the law, and the owner removed the industrial waste began with the cleanup of the sites. Although those pollutions are not serious, however by the time the study had been done in 1999, sites had significant VOC contamination, and pollution did not stop there, the cost of spin-off negative externality to the nearby farm land and natural environment would probably be borne by society instead of the unconscionable individual who caused this debacle, since the punishment for the environmental pollution is not severe enough to deter similar events from happening in the future.

Another serious pollution case that illustrated how weak the environment regulation is and how easy it was to bend the law for the sake of economic development is the Sheng Li and Eternal Chemical case, and this case is also important in demonstrating how lack

of the infrastructure of waste treatment can spread the pollution.

Sheng Li was the only premier industrial waste treatment organization in the country,

which was able to treated general industrial waste and hazardous industrial waste. It

was also the only legal handler of the waste solvent in Taipei County⁵⁴. As Taipei

County is a well-industrialized area and fairly near to the Hsinchu Science Industrial

Park, therefore it was estimated that Sheng Li handle 412 firm's waste solvent, which

included 80 percent of the firms operate in Hsinchu Science Industrial Park. Eternal

Chemical Company started out producing synthetic resin for the paint. In 1985, with

transformation of the industry, Eternal Chemical started to produce chemicals needed

for the semiconductor industry and it has branch out to produce chemical needed for

the TFC and LCD. Sheng Li was commission by the Eternal for treatment of chemical

waste, as did many other companies in Taipei, Toayuan and Hsinchu areas.

But instead of processing the waste chemicals, Sheng Li dumped the chemical into the

Kaoping river, which cause serious water contamination. In a report by Mun Sang

news paper, illegal dumping of the hazardous industrial wastes is extremely profitable,

since proper treatment of a ton of wastes cost around NTD 8 000, so a full truck load

of 25 tons cost around NTD 200 000. But illegal waste handler was pay NTD 10 000

per a full truck load, which makes it low cost to the companies involve, because they

⁵⁴ "Illegal discharge of Sheng Li." *China Times*. 19 Jul. 2000 7 Jul. 2004
<<http://contest.ks.edu.tw/~river/rivernews/2000news/200007/200007-15.htm>>

are able to save NTD 190 000 per full track load, so companies would be able to save millions of New Taiwanese Dollars per month. There is very little incentives for companies to carried out the waste treatment required by law, in the competitive market it is a way to decrease cost without affecting the quality of the products or service.

Waste Disposal Act was incorporated in 1974, amended in 1985 and 1999 with the intention of properly regulated the hazardous waste disposal, and hopefully would be able to encourage the lawful treatment of it by the firms. The provisions thirteen, seventeen, and twenty two have serious implication.

Provision seventeen enables officials from EPA to enter into the facility premises to investigate, collecting samples, and demand relevant information from the firm.

However this provision is not useful in prevention of pollution, since firms could get caught in illegally discharging waste solvent into river, and was given fine for violation of water pollution act, but no further action can be taken.

Under provision thirteen, when illegal dumping of hazardous chemical cause environmental pollution, company and the agent that were contracted to deal with the industrial waste are both responsible for the cleanup of the waste and environmental

restoration. This provision provided the link of duties between the firms and waste disposal agent, which means firms would have motivation to keep an eye on the waste treatment process of its agent, since firms were liable for any damage caused by the improper treatment, therefore principle firm has to bear as much responsibility for pollution as the actual firm that caused the pollution under provision thirteen. However in 2001, this provision came under attack of the industry during the Conference of Economic Development⁵⁵, the pressure was on the new DPP government to put economic/industrial well being first, and also Eternal Chemical case⁵⁶ had increased the pressure on the EPA to change the law to suit the demand made by the government and industry. The provision thirteen was amended again to decrease the responsibility of the firm when environmental pollution occurs, and one adjustment to the environmental evaluation was added as well, which was discharge of waste of firms within Science Industrial Park under allowed pollution level do not need to conduct environmental assessment⁵⁷. This was one giant step backward in the environmental movement, and also shows what is the priority of the new DPP lead government.

Provision 22 sets out the punishment for the violation of the act, incentives for firms to have proper treatment for the hazardous waste and procedure, reward for citizens to

⁵⁵ Lee, C. C. *Protested against failing of environmental regulation*. Environmental Information Centre. 13 Jul. 2004 <<http://e-info.org.tw/against/2001/against-01061101.htm>>

⁵⁶ Lee, C. H. "Traditional Industry look up, future of an old chemical company bright" *Wen Bao Weekly*. 14 Feb. 2004. 13 Jul. 2004 <<http://www.e-stock.com.tw/Report/Report.asp?ID=89955>>

⁵⁷ "Economic guilty? – Is sacrifice environment for economy necessary evil?" *Environmental Information Electronic Paper*. 3 Jul. 2004 <<http://mx.nthu.edu.tw/~hycheng/2green/2001All.html>>

report illegal dumping.

Table Ten Comparison of Provision 22 before and after amendment⁵⁸

Before amendment	After amendment
Suspension of work, close shop, fines	Suspension of work, close shop, fines
No criminal liability	Criminally liable Death: 7 years or above Causing illness: 3 to 10 years Violation of law: 1 to 5 years, and fines up to 1 million. Operation without permit: 3 to 10 years Duty to report: up to 3 years imprisonment and/or 50 thousand in fines.
Not effective	Ineffective

In the past, punishment for violation of the act had been suspension of work as can be seen in Table Ten, and often firms would secretly start operation as in the case of the Hsinchu Chemical Company, it was somewhat difficult for the EPA to monitor the

⁵⁸ Wu, S. C. & H. D. Chung. Influence of new industrial waste regulation." *Prevention of industrial pollution*. Aug 1999. 14 Jul. 2004 <<http://www.etdc.org.tw/month/M137-04.htm>>

suspension. And there were no criminal liability for violation of the Act; it is obvious that the punishment was not severe enough to deter the illegal dumping by the firms.

Criminal liability was added with the amendment of provision 22, which stated if the improper treatment of hazardous waste causes:

-Death: sentence could be life imprisonment or seven years and above.

-Serious injuries or illness: three to ten years' imprisonment.

If firms act in violation of the act⁵⁹, sentence of imprisonment from three to ten years, and fines up to NTD 1 million. If firm operate without permit, could be sentence to minimum 3 years and maximum 10 years in prison. If there is duty on the firm to declare the amount of waste treated, and false report was given, then sentence of 3 years and/or fines of NTD 500 thousand could be given.

Even after amendment, the provision 22 did not provide much more incentives for firms to treat hazardous industrial waste as per requirement of the Act, because the punishment was not harsh, as can be demonstrate in the case of Eternal Chemical.

Although they were given the suspension of work punishment, it was easy over riding it by applying pressure in the right area, because they were an important chemical

⁵⁹ Violation of the act included the following:

1. Dumping of hazardous industrial waste.
2. Firms did not handle, store and recycle waste as per instructed in the Act, which in terms cause pollution.
3. Property use as landfill without permission from authority concern.
4. Handle waste without permits.
5. Knowingly contracted agent who is without permit or unqualified to handle hazardous industrial waste.
6. Dishonest in reporting amount of waste handle by Waste treatment organization.

provider to the semiconductor and TFC/LCD industries, it was suspect that the rent seeking activity was involved in the decision by Kaohsiung High Court to allow Eternal to resumed work. As for the fines, it was peanuts compare to what companies did not pay for the proper treatment of the chemicals. Take the Eternal case for example, the profit from every dumping of hazardous waste was NTD 190 000⁶⁰, split it two ways between Sheng Li and Eternal means basically each company gain NTD 85 000 per each dumping. Each day 3 truckloads were dumped, which means every month nearly NTD 9 million is gain from the dumping for each company. Over the years hundreds of millions of dollars was gained from this illegal activities, so the profit lost during the suspension of work and fines from EPA could not stop the violation of waste disposal act.

In the past twenty years, Taiwan's economic development had been built on the environmental sacrifices. As income raise, people started to paid more attention to the environment, however corporations and entrepreneurs still run their manufacturing facilities as they had before. With environmental awareness increase, more incidents of pollutions by firms are being expose to the public scrutiny, industries are no longer the economic savior, and they are also the environment polluters. It is very important

⁶⁰ Chu, U. Z. "Danger Zone." Online Posting. 20 Aug. 2000. South Community. 7 Jul 2004 <<http://www.esouth.org/sccid/south/south/000802.htm>>

for the firms to be responsible for the pollution damage they had cause in the past, and even more important is to take prevent measure in stop further contamination of the natural environment. In every environmental case it become obvious that government had taken side of the industry, as firms could amass more resources to engaged in lobbying for their interests, and their position in the economy enable their demand to be heard and complied. People who suffered from the contamination have no where to turn to for help and support, often the culprit who were responsible for the pollution could not be identify because source of pollution is from Industrial Park, as can be seen from the pollution in the rivers near Hsinchu Science Industrial Park.

The pollution cause by the Hsinchu Science Industrial Park are undeniable, and often there is sense of helplessness when dealing with the pollution in the park, since the laws regulated corporate environmental behavior were lenient, although the firms could be criminally liable for the pollution, but often culprit could not be identified, or the identity of the perpetrator is know but the punishment deal out was light compare to the sentence demanded by the district attorney (as in Eternal and Sheng Li case).

The punishment for the pollution is often fines, and amount was small compare to the revenues semiconductor facility could generate, so firms would happily pay the fines that allow them to pollute legally. Under the Water Pollution Prevention Act, firms

that discharge wasted water through sewage system could be fined from NTD 60 thousand to NTD 600 thousand⁶¹. This amount is insignificant as can be seen from the cases such as Eternal and LCY Chemical, the profit from illegal dumping of the waste and production were significantly higher than that amount, since temptation is so great, therefore it's only natural for firms to cheat. The semiconductor industrial had pretty much left unregulated for the past 20 years, the production cycle of this industry had serious environmental impact, from construct dam to have stable supply of water to the treatment of the industrial waste resulted from the production. It's about time government start to regulate and evaluate semiconductor production, while the Capitalist who were enjoy enormous gain on development of the semiconductor production, workers and residence of this small island is suffering consequence of unregulated production. Even the head of Taiwan Semiconductor Manufacturing Company Morris Chang acknowledge that Taiwan had trade in ecology for economic development, and he seems to stress on the importance of environment well being in increasing competitiveness of Taiwan on the global market. It was all good and well that the Capitalist paying lip service to the environmental care, just because a company had ISO certificate or practice ESH policy (Macronix) does not mean they are really taking care of the ecology and their workers. But in the end what have those

⁶¹ Ka, C. B. "Danger of pollution." *Hsinchu Foundation*. 10 Jun. 2001. 23 Jul. 2004
<<http://www.hsinchu.org.tw/20010610.html>>

companies do to decrease production impact on the environment? It is unrealistic to ask the firms to decrease production, and in the ISO 14001 that a number of semiconductor manufacturers were so proud to possess, does encourage firms to be environmental conscious in the following directions⁶²:

1. Environmental Assessment: in which firms were to assess the impact their action will have on environment, it was to try to improve action that are environmentally damaging, and does not prohibit actions that could cause damages to ecology.
2. Environmental Risk Analysis: firms should find more environmental friendly way to produce, for example: instead of discharge waste water every day, it should be stored and recycle so it could be discharge once every month, or found some substitute for the highly toxic chemicals that are used in production. But this just means that the waste would be accumulated for a month and it will be discharged in large quantity, and as Taiwan semiconductor production caught up with overseas production, it means we will be experiencing with chemical first handed, so how do the producers, workers know the effects of the chemical on environment or human, much less than found a substitute.
3. Product service: it's idea that firms should take care of the products from beginning to the end, however in order to implement this firms had to offer this

⁶² Huang, K. B. "Improve environment." *Industrial Development Bureau*. June 2002. 24 Jul. 2004 <http://she.moeaidb.gov.tw/issue/issue9/roundup9_2.htm>

service, unfortunately right now there is no firm in Taiwan that offered this service, nor are they likely to offer this service without government requirements as in the cases of Japan and German.

4. Management of resource and energy: firms should adapted equipment that is relative less energy intensive.

The certificate such as ISO 14001 would be meaningless if firms had no intention of follow the direction set up by it, once the firm had received the certificate, it has the responsibility to act in accordance with regulations of such certificate. It seems that firm had treated certificate like a front for their more illegal activities, without continuous environmental performance certificate offer no reassurance as to the environmental policy of the firm.

One of the difficulties in dealing with the pollution by the high tech production is that the environmental regulations were not made for this industry. The present test for pollution main test for the substances listed in the Table Two, but many toxic chemicals are used in the semiconductor production process, the present test does not test for the toxic substance. So even if the contamination does occurred, it is difficult to prove pollution, because legally toxic substance does not mean pollution, and by the time test for toxic substance was performed it has become too late for the workers and local residence.

In Taiwan firms lack commitment to the environmental protection, and neither government nor society encourage firm to be more environmental friendly in production. Therefore in most cases of pollution, public have relatively little information regarding to the incidents. Under the present laws, it was unlikely to hold firm responsible for the pollution they caused, and without that legal obligation firms are not legally responsible for the cleanup of the pollution, society end up with the burden.

3.3.3 Environmental Monitoring Team

The Environmental Monitoring Team in Hsinchu Science Industrial Park was establish to monitor the environmental performance of the park, the members of the team included specialists, environmentalists, government officials, representatives of local residence, and representatives of the park and firms⁶³. The funding of the team is contributed by Management of Hsinchu Science Industrial Park, which means this team is depended on the management of park, instead of being autonomous. Because of the members on the team they were more concern with activities that are affecting the nearby residence. As can be see from Table Five in chapter 2, the production

⁶³ Environmental safety. Hsinchu Science Industrial Park. 24 Jul. 2004. 24 Jul. 2004
<http://www.sipa.gov.tw/index_apis.php>

activities in the park had affected living standard of the local residence, who are separate from park by a wall⁶⁴, the most serious problems been the water pollution, air pollution from the waste treatment facility and around sewage. At beginning the Environmental Monitor team had been ineffective, since they could not get to the root of the problems, and normally go with what was suggested by the management of the park for examples the waste solvent that was dump into the sewage system had cause unpleasant strong odor that were causing illness of the people live in Gao Tsuey (高翠), Ai Min (愛民), I Min (義民) Road, Long Shan Community (龍山社區), Presbyterian Bible College and the park management's solution had been "put a lid on it" and the Environmental Monitoring Team instead of insisted on tracing the problems to it's root had meekly accepted this solution⁶⁵. However as they had more experience in the job, they tend to be more aggressive and demanding, as mentioned before their main function was to monitoring, and they fell under the administration of park management therefore they do not have the power to implementing new regulations or force park management to behave in an environmental friendly way. And because they do not have the power of implementation, the power of implementation is with park management, therefore their advice was not heed by the

⁶⁴ Byster, Leslie, and Ted Smith. "From Silicon Valley to Green Silicon island: Taiwan's pollution and promise in the era of high tech globalization" 18 Oct. 2004. Silicon Valley Toxic Coalition. 18 Oct. 2004 <http://www.svtc.org/icrt/asia/taiwan3_01.htm>

⁶⁵ Meeting minute of Hsinchu Science Industrial Park Environmental Monitoring Team.

park management and firms. As Hsinchu Science Industrial Park do not have environment protection department, it is to be wonder how advice from monitoring team is been put to use? And what is the result of the implementation?

The total level of pollution allowed for the park was set without consultation with environmental groups, local residence and Environmental Monitoring Team, as this decision will have great impact on the living standard of the local residence and it is only fair to allow them some say in the setting of the pollution level, as we are living in a democratic countries, the decision making process should be transparent⁶⁶.

However people were not the only one who opinion were ignored, the local government who lack the authority and resources to control activities in the park, since the central government receiving bulk of the revenue from the park, and the rent seeking acting by the entrepreneurs take place within the high rank bureaucracy, large firms within the park is a power to be reckon with, in the fight between UMC and Hsinchu City government⁶⁷ had demonstrated this very clearly.

Companies and government had been stressing the importance of environment in the

⁶⁶ Huang, T. U. Report of Hsinchu Science Industrial Park Environmental Monitoring Team. Hsinchu Science Industrial Park. 8 Feb. 2004. <<http://www.sipa.gov.tw/evm/upload>>

⁶⁷ Chung LC. High-Tech Fantasies: Hsinchu Science Based Industrial Park and Local Development. 2001.

UMC's fifth production plant had not conducted environmental assessments prior to the operation, and EPA had not demand it of them until the operation is ready to start, and production plant was shut down by EPA, and numerous fines given. UMC claim that they had been unjustly wrong, and the city government is conspired against the firm, and that city government mayor and officials obtain illegal gain. In the end central government mediate between the two parties, both side agree to settle the dispute, however Hsinchu City Mayor, secretary, and department head of Hsinchu EPA was charge with misconduct and sentence to one year to two year and six month, UMC won the fight on all round.

sustainable growth of Taiwan economy, however it's time for them to stop paying lip service to this crucial issue, and start to take environmental cost into account when making decision. Since this cost will be bear by the government and people, and the capital knows no national boundary, therefore they could not be depend upon in the long term, one way of achieving the sustainable growth is by preserve ecology and healthy workers, not by promoting interest of the entrepreneurs.

3.3.4 Failings of Taiwanese government

The developing countries had always been exploited by the developed nations ever since man started to trade between countries. Today the developing nations faced exploitations not only from the foreign firms but also face worst threat from the industries that were promoted by the national government. As developing countries were less concern with ecology than the developed countries, the environmental conscious is a luxury goods, higher the income level higher the conscious, at home the cost and environmental regulations were high, in the quest for cheap labor and increase competitiveness firms had shift production or outsourcing the jobs to the developing nations.

Back in the 70s, in the quest for the global competitiveness, Taiwan had inaugurate

technology know-how of semiconductor production from the United State, the docile labor, lack of environmental regulation and government support had made semiconductor industry the success it is today. However almost 30 years had passed, environmental and workers protection had not grow with economic growth, with weak local government, and powerful firms that have connection in the central government, ecology and health of workers were often neglected, and environmental regulation were behind the time, and no custom made regulation for the semiconductor sector the largest industry in Taiwan.

California has highest concentration of superfund sites, there are 29 superfund sites and 20 of those sites were result of the high tech electronic industries production⁶⁸, this is an example to all the countries that are pursuing economic without regards for the ecology, and this is also what Taiwan is already suffering at the moment.

In US people are much more environmental conscious, therefore there is the Right to know. This is the idea where every American has the right to know the chemicals to which they may be exposed in their daily living. Right-to-Know laws provide information about possible chemical exposures⁶⁹. EPA provided Toxic Release Inventory, which provides information to the public about releases of toxic chemicals

⁶⁸ Mazurek, Jan. *Making Microchips: policy, globalization, and economic restructuring in the semiconductor industry*. Massachusetts: The MIT press, 1999.

⁶⁹ *Right to Know*. U.S. Environmental Protection Agency. 24 Jul. 2004
<<http://www.epa.gov/epahome/r2k.htm>>

from manufacturing facilities into the environment through the air, water, and land.

This mean there are at least some degree of the information transparency between firms and the consumers, and people know what kind of risk they are facing with environmental pollutions. In Taiwan, very few is know about the toxic chemical that is use in the semiconductor production, this kind of information is term trade secrete by firms, and it is doubtful that even Taiwan government knows what semiconductor industry is releasing into the atmosphere, so the citizen is even more ignorant about it. At same time the amount, position of the hazardous materials were regulated by Toxic Gas and Hazardous Materials Storage Ordinance⁷⁰, the hazardous material is control by the government, the Toxic Gas Ordinance is to control the level of pollution and Hazardous Material Storage Ordinance is to know quantity and position of the hazardous material in the production facility so in disaster rescue workers would not be endanger by the toxic chemical on the compound like the fire disaster that occurred in Hsinchu Science Industrial Park, where the fire fighters would refuse to enter the production facility due to the danger pose by the toxic chemical⁷¹. And as the space in Taiwan is scarce, it is the second most densely populated country, and population is most clustered on the Western side of Taiwan. As the different zoning were very close

⁷⁰ *Toxic Gas Ordinance at Stanford*. Stanford University Environmental Health and Safety. 24 Jul. 2004 <<http://www.stanford.edu/dept/EHS/prod/researchlab/lab/tgo/>>
Requirements for Hazardous Materials Reporting. City of Palo Alto. 24 Jul. 2004 <<http://www.pafd.org/business/hazmatreportingquantities.html>>

⁷¹ Huang, T. U. Report of Hsinchu Science Industrial Park Environmental Monitoring Team. Hsinchu Science Industrial Park. 8 Feb. 2004. <<http://www.sipa.gov.tw/evm/upload>>

to each other, for example Hsinchu Science Industrial Park were separate from local residence by a wall, and this cause all kind of problem, air, water, traffic, noise.

Because people live close to source of contamination, their living standards are also seriously affected by those pollutions.

Most recently the US environmental programs like Common Sense Initiative and Project XL tend to try to find ways to establish laws at lower cost of time and money, at same time they want the laws to be relevant to the industry that they were suppose to be regulating. The Common Sense Initiative is to producing better, more applicable environmental protection strategies that are developed by those who have to live with them, avoiding costly and time consuming adversarial processes later⁷². And it bring together all parties concerned government, industry, environmentalist, labor, and EPA, to make recommendations as to what is the most suitable regulations to the high tech electronic industry. While this idea was excellent, but there were also many pitfalls, such as the advisor on the board were normally on the opposite side of issues, it's difficult for them to forgive and forget and work together. At same time Common Sense Initiative do not have the power of the laws and lack the resources it needed to succeed. Soon the firms feel that they had not been benefit from CSI, and it fail to provide firm with incentive to provide information regarding the environmental

⁷² *Region 7: Common sense Initiative*. U.S. Environmental Protection Agency. 25 Jul. 2004
<<http://www.epa.gov/region7/p2/volprog/csi.htm>>

problems they had been experiencing and the data from the production plant. This initiative ended by 1998, it was a good try by EPA, in getting all the players involved to develop a socially beneficial plan to prevent pollution⁷³. Project XL, which stands for "eXcellence and Leadership," is a program that allows state and local governments, corporations and federal facilities to develop with EPA innovative strategies to test better or more cost-effective ways of achieving environmental and public health protection⁷⁴. As this program is to design the tailor-made regulations to each production facility, it is obvious to see that the costs of such exercise are far too great, therefore making it unpractical, as such high costs would mean a fall in the competitiveness of the firm. At this point no one had perfect environmental protection, therefore new programs should be tried in order to improve existing regulations. Common Sense Initiative and Project XL are to reduce the responsibility of government by promoting greater public participation. But the creative destruction of the industry and the information intensiveness of the semiconductor sector defeated public efforts to assess and monitor how well regulations really work. In Taiwan the environmental protection effort by government is always one step forward and one step backward as can be seen from the Eternal case, the entrepreneurs conspired to

⁷³ Mazurek, Jan. *Making Microchips: policy, globalization, and economic restructuring in the semiconductor industry*. Massachusetts: The MIT press, 1999.

⁷⁴ *Project XL-What is Project XL?* U.S. Environmental Protection Agency. 25 Jul. 2004 <<http://www.epa.gov/projectxl/file2.htm>>

exert pressure on government, local government lack the authority to regulate production, the lack of co-operation between each governmental departments makes it even more difficult to ascertain the correct data of pollution and toxic chemicals.

In US the environmental Non Governmental Organizations had played an important role in the decision making, they were included in the programs such as Common Sense Initiative and Project XL. Silicon Valley Toxics Coalition is a Non Governmental Organization that specially target at the social and environmental problems cause by the high tech electronic industry. It was formed in 1982 in response to the discovery of substantial groundwater contamination throughout Silicon Valley that was caused by toxic chemicals that leaked out of underground storage tanks from high-tech companies⁷⁵. SVTC has tried to raise the environmental consciousness and performance of the high tech electronic industries. Also they goal is to expanded the awareness of the toxic legacy of high-tech development and moved the industry to eliminate some of the most toxic chemicals and to begin to adopt more sustainable practices. Its members consist of professional in the field of labor, law, and occupational health, it sponsor studies on the effect of the pollution on environment and labor force. The other NGO such as Nautilus Institute and EnvironLink Network,

⁷⁵ *What is Silicon Valley Toxics Coalition?* Silicon Valley Toxics Coalition. 25 Jul.2004
<<http://www.svtc.org/about/index.html>>

had sponsor projects such as the Corporate Global Accountability Project which provided reports on the influences of global production of technology on the environments. The NGOs in US are much better organized than their Taiwan counterparts, and much more specialized, for example Hsinchu Foundation which is the environmental NGO in Hsinchu district, it is sort of jack of all trade, and not really specialize in the high tech pollution. It is very difficult for the Taiwan NGOs to focus on certain issues since the attention span of Taiwanese people are fairly short, and news concern ecology normally doesn't generate attention. Especially for the last 3 years the global economic had face downturn and the excess inventory of the high tech good cause downfall of the earning of the high tech sectors in Taiwan since the large firms had decrease order for the semiconductor. The global situation had mean that the ecology had to be neglect, since for firms it means time and money to decrease pollution and this affect competitiveness. The environmental NGOs in Taiwan lack influence and their criticism of the firms mainly about their capitalistic production and possible influence of the pollution. However the environmental NGOs in Taiwan lack professionalism and resources that will allow them to engage in lobby for their interest.

In order to achieve sustainable growth, all parties had to co-operate to provide

possible solutions, although the result might not be successful, but with symmetric information between parties would be benefit to society. The government had to protect it's people in order to achieve sustainable growth, especially in Taiwan which is an island lack natural resources therefore only the quality of the workers could be rely upon. It is important for government to provide incentive for industries to provide information on production. In the long term it would be beneficial to all parties concern, and best possible regulations could be establish, at the moment Taiwan still rely very much on the corporation's concern of their business reputation to control pollution, but it has been show ineffective in the case of RCA.

Corporations had exploited island's ecology and workers to gain unstable competitiveness, and they all paid lip service to been environmental conscious, but they had behave in the way that is gross negligence toward ecology and workers.

Although in the way part of the problem is that there is not enough proper waste treatment facility in Taiwan, as the growth of such facility has fallen behind the growth of production. At same time the monitor system of government lack the authority and resources to make they effective, and that add to the incentive for firms to behave in the way that is irresponsible.

To Marx by using the surplus value as capital and the resulting surplus product is converted into capital, accumulation of capital has occurred. In the modern production

resources (capital) are pool together, so that production would be economized by concentration on a large scale (544). As Marx was most concern with the workers, he bases his arguments on the exploitation of the labor force, however in the world of the fragile nature, the exploitation of nature by the capitalistic production has become very important as well. The capital accumulation is increasing mass of wealth, which increases the concentration of that wealth in the hands of individual Capitalists, and this growth would negatively affect social capital (Marx, 586). This idea is radical since the economists prior to the Marx believe that the accumulation of the capital in the hands of private individual would raises the social capital and that would lead to the raises in social welfare. In the global market today the competition is fierce, therefore competitors compete with each other's prices, but providing the same product at low price, the market shares would increase. However by the cheapening of the commodities, the true value of the commodities no long reflected on the price people pay for the commodities. As the price no longer reflect true value, people became less appreciative of the commodities and would act in wasteful manners, this would create unnecessary waste, and society have to store and process those waste, and many of the wastes are toxic to the environment thus damage the ecosystem. As the Capitalist accumulated the capitals, they gain enormous financial and political powers, since with control of large resources they are able to influence government's

decision, and further their own interest.

The last twenty years was the period of capital accumulation for Taiwan, with industrialization vast economic growth was achieved, as Marx cautioned this growth is not without its price. That price is sacrifice of workers (emphasized by Marx (586)) and (as the nature resources become less abundant) the environment. With large accumulated capital, Taiwan is now in the role of the exporter of the capital to the third developing nations, such as China, Indonesia, Philippine etc. As the production method remains unchanged, and the weak environmental regulation of the third country, the firms behavior is unchecked, this create fertile ground for the contamination of the environments. Therefore Taiwan has not only shift out the capital but also the pollution. This has becomes the pattern of global capital movement, and Taiwan has suffer from this ever since the 60s, pollution comes with foreign investment just as demonstrated in the case of the RCA and Philips contamination. And as capital shift out of Taiwan, the pollution cause by the capitalistic production left behind, the social cost of treating the pollution was too great, and social capital which has been negatively influence by the growth of individual capital can not cover that social cost. Therefore Taiwan is just another example of the price that developing countries paid for the economic growth, at same time Taiwan is also an example to the other less developing countries.