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Environmental Problems Associated with the Paint Sector in Pakistan and their Assessment

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Abstract: This paper addresses the environmental problems associated with the paint manufacturing sector in Pakistan, based on the findings of the environmental audits of paint industry. Factors effecting environment, health and quality of life such as air emissions, waste water, solid waste and high level of noise are highlighted. Possible solutions and estimated required investments are recommended to mitigate these problems in order to comply with the present and future environmental legislation in Pakistan.

Key words: Varnish, pigments, paints, wastewater.

Introduction

The paint industry in Pakistan operates both in the organized as well as the unorganized sectors. According to an estimate, over 350 units producing paints and varnishes are operating in the unorganized sector, resulting in low standard and cost of the paint product. The paint industry uses about 300 different types of raw materials for producing various kinds of paints. About 15 percent raw materials of the industry are petroleum-based. In 1971, between 80 to 90 percent requirements of the raw materials were met through imports, which currently have been reduced to about 40 percent due to increased production of indigenous raw materials such as mineral turpentine, resins, vegetable resins and gums. The major imported raw materials include pigments, zinc oxide and titanium oxide. The imports of major raw materials of paint industry are given in Table 1 (FBS, 1998a). However, with rise in production of petroleum products and development of chemical industry and manufacture of titanium dioxide, lithopone imports are reduced.

From data analysis, production of paints and varnishes is concluded to be erratic during 1990-91 to 1997-98 (FBS, 1998b) given in Table 2. The dip in production is attributed to the shortage of raw materials, contraction in demand for certain paints due to slump in the sectors that produce paints, low level of efficiency, etc. The production of paints was reduced to half in 1997-98 as compared to 1990-91. During the same period varnishes also registered a declining trend. From data in Table 2**,** Pakistan's export performance with regard to paints and varnishes is concluded not very encouraging. In terms of value, exports touched the highest in 1997-98 at Rs. 122.907 million. The exports touched the lowest at Rs. 5.665 million during 1989-90 (FBS, 1998b).

The demand for paints and varnishes is derived from expansion in construction, building, manufacturing, transport and other sectors. The demand for paints is conservatively estimated to increase by 20 percent annually during the next five years (IRS, 1998). This shows a sizable potential for further strides in the country's paint industry. Moreover, the development of chemical industry is also taking place and, therefore, most of the raw materials used by the paint industry are expected to be produced and manufactured locally during the next five years. The paint industry would thus find cheaper raw material for further expansion and growth.

Table 1: Import of major raw material from 1994-95 to 1997-98

Raw Material	*1994-1995*		*1995-96*		*1996-97*		*1997-98*	
	Qty (ton)	*Value ('000 Rs)*	*Qty (ton)*	*Value ('000 Rs)*	*Qty (ton)*	*Value ('000 Rs)*	*Qty (ton)*	*Value ('000 Rs)*
Pigment-based titanium	5956	350951	6069	421218	5631	335810	7266	594674
Pigment-based chromium	211	13290	277	18807	455	35558	340	30626
Titanium dioxide	1087	70517	1178	90522	1324	109859	—	—
Lithopone	3110	34985	2784	51313	2534	56830	935	18982
Zinc oxide	1383	29546	439	17637	466	20482		
Aluminum powder and paste	104	19776	128	14111	122	15664	87	12685
Stamping foils	42	6022	40	6837	123	26103	—	—
Titanium oxide	130	5486	362	22767	280	24881	—	
Pigment-based cadmium	8	1035	318	21571	6	1255	—	—

Table 2: Production and exports of paints and varnishes

Year	*Production of paints(1990-91 to 1997-98)*		*Exports of paints and varnishes (1988-89 to 1997-98)*	
	No. of units	*Value ('000 Litres)*	*Quantity (Tons)*	*Value ('000 Rupees)*
1988-89	—	—	664	13188
1989-90	—	—	298	5665
1990-91	90	19174	—	15940
1991-92	50	18553	—	26967
1992-93	63	23323	—	20964
1993-94	64	16112	—	15068
1994-95	36	15524	320	33734
1995-96	46	14848	210	44038
1996-97	87	16688	—	83270
1997-98	87	17000	—	122907

Usually the raw materials used at paint industries are pigments, resins, extenders, solvent turpentine, additives, water and filler. Pigments are those compounds, which impart colour in the products. Fillers such as clay and chalk are used to provide body to the paint. Extenders provide a consistency in the properties of the paint such as gloss. Raw materials such as resin, pigments, extenders and additives are further classified as water soluble and those which are soluble in the solvent. Paint industries produce a wide range of finished and intermediate products which include pigments, distempers, plastic emulsion, enamel, undercoat, primers, rubber paint, aircraft paint, marine paint, anti-corrosive paint, anti-fouling paint, etc.

Manufacturing of solvent-based paint involves grinding and mixing of raw material. No chemical reaction takes place in this process. Some paint industries manufacture two types of automotive paints, one that requires baking after application and other which is prepared in highly vaporizable solvent thus eliminating the need for baking. Durocem is powder-based paint, which is applied on the exterior of the building. The process involves grinding and mixing of different raw materials, which also include cement. Resins, flow agent, anti-bubbling agent, pigment and fillers are used as raw materials for manufacturing of the powder coating paint. Mainly two types of water-based paint are produced in Pakistan. These are distemper and plastic emulsion. Details of manufacturing processes of all above are given in a report (ETPI, 2000a).

Environmental Problems of Paint Industry

Major environmental problems are concluded due to wastewater generation (process and domestic), used solvent emissions and disposals and air emissions.

Waste Water Generation

The main source of **process wastewater** in any paint industry is the manufacturing plant of water-based paint. This plant is equipped with mixing machines including dispersers and kneaders, reaction kettle, condensers and pressure vessels. Waste water is generated due to the washing of these machines and from the pigment section.

Waste water from laboratories is generated due to washing of utensils. It is observed that usually the process wastewater is discharged without any treatment.

Domestic waste water from washrooms, toilets, and kitchen is usually discharged into sewerage line without treatment, with a very few industries having installed septic tank.

Approximate **quantities** of waste water generated from a typical paint manufacturing industry (ETPI, 2000b) are shown in Table 3. These depend on the number of people employed and is estimated on standard daily consumption of 40 litres by an industrial worker and are calculated on the basis of average per capita consumption of water. The quantity of process wastewater (3–7 m^3/ day) is estimated for a normal operating day, for a typical paint unit. However it would depend on the size of the industry, as well as its production capacity and frequency of cleaning.

Table 3: Types of waste water and their typical quantities

Types of waste water	*Quantity per day (m^3)*
Domestic	2 – 8
Process	3 – 7
Laboratory	1
Total	6 -16

Characteristics of Waste water

On the basis of data collected during the three environmental audits (Table 4) results show that the levels of parameters are much higher than the prescribed National Environmental Quality Standards (NEQS). This is mainly due to the presence of inorganic pollutants. Waste water generated by pigment manufacturing process usually contains high levels of heavy metals, such as lead (~200 mg/l) and chromium (~2 mg/l) against the respective NEQS, 0.5 mg/l and 1 mg/l.

Table 4: Characteristics of waste water

Parameters	*Typical range*	*NEQS*
pH	8-13	6-9
Totally dissolved solids (TDS) (mg/l)	500-1100	3500
Chemical oxygen demand (COD) (mg/l)	6500-11500	400
Biological oxygen demand (BOD) (mg/l)	100-500	80
Total suspended solids (TSS) (mg/l)	2800-3800	200
Settable solids (mg/l)	2500-3000	1
Copper (mg/l)	1-35	1
Zinc (mg/l)	0.07-0.15	5

Almost 90-300 litres of **used solvent** is generated per day from a solvent-based paint plant. In some industry, this solvent waste is reused in the process, but if the quality is low, it is disposed off through a contractor. Some industries mix all the polluted solvents and sell it to the free market. It is ultimately used by the street automobile workshops. It is obvious that finally the heavily polluted solvent mix will end up in the environment. The solvent evaporate completely with the non-volatile pollutants left over or spilled on the ground (ground water) or in water.

Air Emissions

In solvent-based paint manufacturing plant, mixing vessels are not equipped with any lid, resulting in emissions of volatile organic compounds (VOC) into the production hall during the operation.

In pigment grinding room, dried lead chromate is ground by a chopper and fine pigment particles are emitted in the form of dust. Air bag is used to trap these particles; however it is not sufficient.

Lead bars are melted and then instantly cooled in the water. This process gives lead a flowery soft structure. Melting is mostly carried out in an open pan at atmospheric pressure. Lead vapours are evaporated during heating process.

When raw materials, in dry powder form, are charged into kneaders, fine particles in the form of dust emit in the working area. The magnitude of dust emission is quite significant as the workers, who charge the material manually, get covered by dust. The dust is inhaled by workers as well as it comes into direct contact with their skin and eyes.

Only a few industries have implemented some **effective measure for controlling air emissions** such as dust and fume collecting system with each machine. Dust is ultimately collected into the bags and removed periodically, while fumes are passed through the stack into the atmosphere.

Solid Waste Generation

Solid wastes generated from a typical paint industry mainly consists of empty containers, empty paper and polyethylene sacks, used solvent, used filter cloths, cotton waste, scrape drums, aluminum, tin scrape and sludge. Apart from cotton waste and sludge, all solid waste has some economic value; therefore they are usually sold to a contractor.

Mostly the workers use cotton waste for cleaning the solvent-based mixing vessels. They clean these vessels

by mopping the paint with cotton. Cotton waste thus generated is stained with paint and soaked in solvent. All cloth, especially the cloth used at the solvent paint production site, should be considered as chemical refuse and therefore should be handled in a careful and organized way.

Used filter cloth is generated as waste after it has been clogged with lead chromate fine particles. Usually these wastes are disposed off by solid waste collecting service.

Plastic and metal cans of raw material are rendered as waste when their content is used. Usually they are sold to the contractor.

Acid chambers are plastered with concrete; acid strip off the plaster and attack on the structure. As a result, sludge has to be cleaned off from the bottom of acid chambers every month and dumped. This sludge may contain concrete, substantial amount of lead, and traces of copper. After every three to four months a new layer of plaster is applied inside the chamber. Solid waste generated from paint manufacturing industries along with its mode of disposal is taken from ETPI (2000b) and summarized in Table 5.

Noise is generated from Ball Mill during reducing the mesh size of raw material. Balls produce a hammer effect and reduce raw material into smaller size as per specifications.

In some of the paint industries acid chambers are equipped with pumps which circulate solution of lead and acetic acid through lead-flowers chamber to obtain maximum yield of lead acetate. These chambers are built at a height, which is more than what is required, thus causing higher pump-head and **consuming more energy** than required.

Table 5: Type and mode of disposal of solid waste from typical paint industry

Type	*Disposal*
Paper, packaging and cotton waste	Through administration/contractor /dumping
Empty cans and drums	Sold
Sludge	Dumped or thrown near factory premise
Rejected containers	Sold
Used filter fabric	Through administration
Aluminum scrap	Sold
Empty cans/drums	Sold
Polypropylene bags	Sold
Used solvent	Sold

Environmental Impact

Impacts of wastewater pollutants such as organic pollutants, particulates and sediments, lead, chromium, total dissoled solids and waste solvents need critical evaluation. **Organic pollutants** with high COD causes total depletion of oxygen in the water body providing an anaerobic environment and are fatal to aerobic life. It is difficult to predict the extent but in the long run it may adversely affect the local fishing industry. Similarly **particulate and sediments** present in wastewater in the bottom of water body, decompose aerobically and an-aerobically, depending on prevailing conditions. Usually they first consume all the dissolved oxygen available and then start decomposing an-aerobically and clog the gills of fishes. **Lead** affects several organs of the human body including the nervous system, blood forming system, the kidney, and the cardiovascular and reproductive system. For plant and animal life, the toxicity of **chromium** salts is variable. **Total dissolved solids (TDS)** are undesirable in receiving water. Dissolved minerals and organic constituents may produce aesthetically displeasing colour, tastes and odour. Some chemicals may be toxic and some of the dissolved organic constituents have been proven to be carcinogenic. **Waste solvent** is sold for down stream uses, but it is feared that finally it ends up in the water or soil environment causing pollution.

Prolonged dumping of domestic wastewater in the land results in **contamination of the sub-soil**. Redemption and cleaning of the contaminated soil strata is a costly and a difficult job.

Potential **impacts by air emission** from typical paint manufacturing industries are volatile organic compounds (VOCs), vapours of lead and dust. Solvent vapours, generated usually from solvent-based paint, contain VOCs, which are phenols and volatile hydrocarbons, etc. VOCs are implicated for their possible role in global warming. When air borne, they react with oxides of nitrogen (NO_x) to form smog. At some paint manufacturing industries workers are directly exposed to VOC and its inhalation results in the irritation of respiratory tract sometimes developing into common allergies to a range of hydrocarbons. Some carcinogenic effects are also reported on human health due to inhalation by the receptor. **Vapour of lead** has an effect on several organs of the human body including the nervous system, blood forming system, the kidney, and the cardiovascular and reproductive system. **Dust (particulate matters)** has certain impacts on human health. The frequency of respiratory infections such as cold and bronchitis

increases with the increase in exposure to dust. It clogs nasal membrane of human and animals. It also causes eye irritation and infections.

Solid wastes such as card boxes, wrapper, plastic container, paper, etc. are sold for reuse. The empty plastic containers of chemicals are used in low-income families to contain food items such as flour, rice, etc. Although containers are cleaned before being sold, chances of contamination of food still exist. In addition these end up in the water or soil environment causing pollution.

High noise is considered as an interference to and imposition upon comfort, health and the quality of modern life. Given the conditions like exposure limit and time, noise may have both physiological as well as psychological effects on human health.

Possible Solutions

A substantial decrease up to 60% in wastewater can be achieved by using high-speed water jet for washing purpose. Using high-speed water jets operated on well water, a clear demarcation between high quality and low quality water can be achieved. Training to workers can help in making this arrangement foolproof.

Using an open sewer system it is easy to clean and monitor excessive product (paint) loss and maximum flow of wastewater. It will prevent the sedimentation tank from being shock loaded and over flowed and thus would improve sedimentation tank efficiency. To measure the efficiency of sedimentation only, a laboratory scale analysis of supernatant of a settled raw wastewater should be done for suspended solids and COD parameters. A batch-wise sedimentation process should be used and the pollution concentrations are determined after sedimentation.

Reuse sediment as basic material in the production of low quality paints. In case this might not be possible, the sludge can be led into filtration vats, equipped with filtering cloth. Separation of water and suspended solids will take place. The filtrate (water) is discharged into the sewer; the suspended solids are dried (solar energy), collected and discharged as solid waste.

Using an in-line-solids-recovery system, optimizing existing sedimentation tank and installing physical-chemical or biological-unit-operation, in the presently existing systems, waste water treatment at comparatively low costs are recommended (ETPI, 2000a).

For pre-treatment, septic tank is recommended for **domestic wastewater**. Sludge, from septic tanks, can be used as natural fertilizer within the factory. Likewise, treated sanitary wastewater can also be used for horticultural purpose within the factory. However, care should be taken for sludge use after ensuring that it does not contain any hazardous compound, as laboratory wastewater includes domestic effluents such as lead chromate.

After usage, **waste solvents should be stocked** properly in gas-tight containers. The containers can be collected and the solvents regenerated by a central service organization working for the paint and other solvent using sectors. Regeneration can take place by distillation. The solvent can be re-sold to the paint and printing ink industry or, if quality is not sufficient, to small car workshop.

At most paint industries, cloth or cotton is used for cleaning purpose. This is used to wipe off paint from the surfaces of containers, machines and vessels, etc. In waste form, cotton is stained with paint and soaked in solvent. Mostly these cotton wastes are collected, stored in bins, and disposed off with other solid waste. Environmentally, the most feasible solution is to incinerate the material in small furnace at high temperature with off-gas treatment. However, as low quantity of waste is involved, and to mitigate this problem action should be done through a central service organization.

Cleaning of **empty container** within the industry should be done with as little solvent as possible. Used/ waste oil should be kept in air-tight container. Intensive re-use of cleaning solvent should be adopted. Reuse of empty containers within the plant should be encouraged.

Using an inner lining of tanks by polyethylene, a safeguard can be provided to the concrete walls against **acid attack**.

Air quality can be significantly improved by reduction of solvent **evaporation** by closing the mixing vessels by lid during operation. In addition, to control vapours from a hole/opening around the central shaft over which mixing propeller is mounted, a blower aspiration system is recommended to suck in all vapours from the plant and pumps it into the air outside.

Charging of powdered materials such as china clay, chalk, and additives causes emissions of dust in the plant and is concluded due to worker's ignorance and the way the kneaders are built. It is recommended that workers should be trained for proper charging and kneaders should be complemented with minor changes by adapting the lid of the kneaders in such a way that the bags can be positioned in a closed surrounding and opened by means of one or more knives connected to the main frame of the machine. After having finished the charging of the system, it has to be left alone for a few minutes to let the

dust inside the machine settle down. Then the lid can be opened and the paper or plastic bag can be removed.

Noises caused by different machines/sections should be controlled by using low noise equipment, altering the process or changing operating procedures, applying conventional methods of noise control such as enclosures or silencers. When neither of these is feasible, the last resort of providing personal protection should be considered.

In lead acetate tower (LAT) to dissolve lead flower in acetic acid, usually a pump is used. To control unnecessary high pump head causing **time and energy losses**, submerging wooden tower into acetic acid solution and to evenly sprinkle acetic acid on lead flower a sprinkler system should be used.

Estimated costs to control wastewater (process and domestic) and air emissions for suggested systems are given in Table 6.

Table 6: Estimated costs to control waste water and air emissions

Problem	*Recommended system/process*	*Cost (Pak Rs.)*
Waste water emissions	Sedimentation (0.42 m^3/day)	110,000
• Process	• Two compartment septic tanks (5.4 m^3)	37,500
• Domestic	• Sedimentation	135,000
	• Micro-Filtration	1,687,000
	• Nano-Filtration	3,615,000
Erosion of acid tanks	Acid resistant lining (per square meter)	1,450
Air Emissions	• Ventilation system	29,000
	• System for handling raw material bags	8,500

General Recommendations

- Good house keeping is of main importance. Procedures on handling refuses should be introduced.
- Cadmium (Cd), mercury (Hg), PCB (poly chlorinated biphenyl), PCT (poly chlorinated triphenyl) or other such materials should not now be used in the paint producing industry.
- In order to control solvent evaporation, all vessels, container etc., that are not used and contain solvents and/or solvent-based paints, should be kept closed and if possible stored at a dry and well ventilated location in the vicinity of the solvent-based paint production.
- Refuses should be kept separate and stocked on a centrally situated, well ventilated, dry and well maintained area. The stocking place for liquid refuses should be equipped with a liquid proof concrete slab with upstanding rims (tub) for preventing liquid materials (e.g. solvents) to leak and/or seep into the soil.
- Attention should be paid to certain health aspects of the operators.
- Cleaning of tankers and other means of transport should be done by specialized companies.

Conclusions

Paint industry in Pakistan can substantially improve its environmental status by taking recommended measures. Not all measures are necessarily appropriate for all units. Individual units have to select options most suitable to their own situations. The recommendations given have been developed and worked out on the basis of the present state of information. For further development and cost estimation of each recommendation, more specific data would be necessary. This can be undertaken at the implementation stage for individual units.

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References

Federal Bureau of Statistics (FBS) (1998a). 1997-1998.

Federal Bureau of Statistics (FBS) (1998b). 1997-1998.

Report of Industrial Research Service (IRS) on Paint Industry in Pakistan-I (1998). IR – Report No. 774. October 20, 1998.

ETPI (2000a) Paint sector report by Environmental Technology Program for Industry. April 2000.

ETPI (2000b) Environmental Technology Program for Industry (ETPI) Survey, October 2000.

Civil Engineering Handbook under Sanitary Engineering Section for industrial category.