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Survey of Health and Environmental Effects of Pollutants of Brick Burners of Yazd Province

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ABSTRACT

Background: Brick burners are considered as the main sources of air pollution in Yazd province due to their inappropriate fuel, being old and traditional fabrication process and lack of a pollutant reduction method. In present paper, which is a descriptive – analytical one through library studies, organizational and field visits, required information including number and type of burners which are active in province, their fuel type and level, brick fabrication process and so on are collected. Moreover, by means of the amount of used fuel and emission factor, level and type of pollutants resulted from brick fabrication in the region are calculated and to make the study quantitative, concentration of pullutants of 20 chimneys were measured using Testo 350-M/XL and compared with available standards and results were analyzed. Results show that 99.97% of the fuel consists of mazut in which industrial furnaces with 330 million liters annually consumption have the maximum share. Results also demonstrate that as a result of burning mazut in brick burners, 27096.3 tons SOx, 4729.5 tons NOx, 168.9 tons HC, 246.3 tons CO and 1351.3 tons PM enters the region air per year and in this regard, value of SOx is significantly high. Since majority of manual furnaces work in a preliminary manner with a great loss of energy, by supplying natural gas instead of mazut, changes in brick fabrication lines, using newer techniques for fabrication lines or organization and transferring available burners to a place outside the city, in addition to reduction in air pollution, fabrication costs and fuel consumption sots will reduce considerably.

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INTRODUCTION

In recent years, concerns regarding uncontrolled increase in energy consumption and its effect on environment has grown [9]. Some challenges facing environment which arise from consumption of various energy carriers include low standard of fuels such as petroleum, mazut and gasoline, low price of fuel, lack of a logical consumption pattern for instructing consumer units and low efficiency of demand sector.

Air pollution is the main problem with which Yazd province residents deal and most of the physicians believe that the reason for increase in cancer rate is emission of pollutants of brick burners and tile and ceramic factories. In addition to environmental pollutions, soil resources of the province are in danger as well, since Yazd brick is well known for using a certain type of soil which is only available in this province and this is becoming a major problem in this region because soil is not a resource which can be renewed and it requires millions of years for recovery. Brick bruners are only useful for fabricators and owners of workshops since they require no resource but soil, water and fuel whose water and soil is supplied from environment and fuel by governmental subsidiess.

Previously, brick burners were located outside cities. However, by extension of cities, these workshops are beside people houses and naturally pose serious problems not only for neighbor people but also for all residents of the province. In this province, brick burners plays the most fundamental role in air pollution so that if in metropolises, the major factor of air pollution are vehicles, in Yazd, the major factor corresponds to brick burners which destabilize the soil by extracting high quality soil for fabrication of brick and tile and

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consequently, as a result of strong storms in desert regions, soil particles become suspended in the air and intensify the pollution and breathing and lung diseases [3].

Nonmetal mineral industries, by consuming about 36% of the oil and gas products and among them brick, tile, ceramic and Chinese industries, by 15% of this consumption level, are of great importance among all industries. Furthermore, in brick industry, there are 7000 active factories which fabricate nearly 50 million tons of brick annually and consume about 4 billion liters of mazut per year. In addition, each month, 35 billion tomans fuel subsidies to 60 brick burners and 140 compressive and industrial furnaces of Yazd province which is a considerable amount compared to provincial funds [3].

The main purpose of this research is to provide an appropriate field and context for activity of furnace owners of the province by means of appropriate utilities for brick fabrication, especially natural gas which finally leads to presenting and implementation of technical and managerial solutions in order to reduce air pollution resulted from the activity of brick burners along with sustainable development of Yazd province and specifically, Yazd city.

Present work is descriptive – analytical research. That is, initially, through library and internet studies, literature is collected and then by visiting relevant organizations, required information for number and type of brick burners, amount of consumed mazut, area of occupied land, method of supplying fuel and amount of regional and national brick consumption and so on are obtained. Then, by visiting the region and field studies, filling out questionnaires and interview with owners of furnaces and residents, technical and professional information was collected. Since in each industry, composition and type of fuel and production technology affect the value and type of pollutants, chemical composition of used soils was analyzed. Moreover, type of brick burners active in the region were recognized in terms of fabrication technology including manual, Huffman and automatic. Then, since one of the effective factors in pollutant emission is the process of production, this issue was analyzed in brick burners as well. Value of mazut consumption was obtained from syndicate of furnace owners and average fuel consumption per tons of brick was calculated. Moreover, using the value of pollutants per liter mazut and emission factor, value and type of pollutants such as CO, NO_x and SO_x for each unit brick and overall pollutants of brick fabrication in the region was calculated.

To make the study quantitative, concentration of pullutants of 20 chimneys were measured using Testo 350-M/XL having two probes, one for measuring combustion gases and relevant parameters and another for measurement of velocity and flow rate. Finally, by having statistical information and measurements, results were compared with available standards and analyzed.

Findings:

Brick is one of the oldest masonries which is fabricated by tempering raw adobe. The main material of the brick is clay and properties which are important in brick fabrication are plasticity, wet hardness, contraction in tempering, volume reduction in the time of rinsing, tendency to cracking and curving.

Brick burning is the process of taking water from clay so that aluminum hydro-silicate is transformed into aluminum silicate and consequently, adobe is strengthened and can support a force as much as 100 kg/cm^2. This is done in 900ºC. The main constituents of brick are: kaolinite, illite, chlorite, brucite as well as quartz, various oxides, carbonates and organic materials. In table 1, composition of the soil for brick fabrication is summarized.

Table 1: composition of brick for brick fabrication.

Acceptable Range (%)	Chemical Composition
40-60	SiO_2
9-21	Al_2O_3
3-12	Fe_2O_3
<7	CaO
<4	MgO

Brick burners are classified into three groups according to production technology:

- Stationary brick and fire
- Moving brick and stationary fire
- Stationary brick and moving fire

In general, the method of fabricating brick can be summarized in three steps: preparing adobe, drying and tempering (firing). Production can be summarized as follows: materials extraction, mud formation, forming, drying and tempering. Fig. 1 represents a schematic of the brick fabrication process [5].

Regional dispersion of brick burners in each city:

Yazd, by 85 furnaces as much as 57.5% of 148 furnaces has the highest number of furnaces. After that, Sadough, with 31 furnace and 21%, Meybod with 20 units and 13.5%, rank after Yazd. Least number of furnaces correspond to Taft with units and 1.35% [3]. Indeed, concentration of brick burners is formed around

Advances in Environmental Biology, 9(2) January 2015, Pages: 917-921

Yazd city. As can be seen in table 2, Bafgh, Taft and Ardakan have the least and Yazd, Sadough and Meybod have the highest concentration.

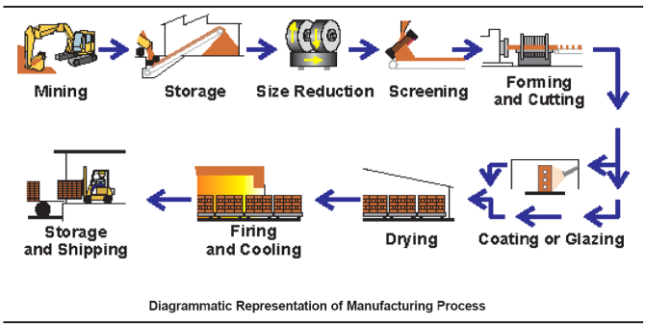

Fig. 1: schematic of brick fabrication process.

Table 2: dispersion of brick burners for each city.

Sum	Yazd								
	Quran Gate to Zarach	Old Bafgh Road	Koucheh Moshir and Saleh Abad	Fahraj	Maybod	Ashkezar – Ali Abad	-Bafgh Behabad	Ardakan	Taft
148	16	40	15	14	20	31	3	7	2

Type and value of fuel consumption in regional brick burners:

Fuel consumed for brick fabrication is mazut which has a high consumption rate. In Yazd region, fabrication is done solely by mazut whose consumption differs among various types of furnaces and always has the highest rate of consumption. In reality, these furnaces require 250 liters mazut for fabrication 1000 bricks; while automatic and compressive furnaces need 80 liters for the same amount of fabrication (Fuel consumption organization, 2010). Statistics provided by oil national company shows that 99.97 of the mazut is consumed in brick burners (table 3).

Table 3: value of fuel consumption for each furnace type in 2010.

Type	Fuel consumption (1000 lit)			
	Annual	Monthly	Daily	QTY
Industrial	330690	27185	906	145
Manual	174835	14382	479	290
Sum	505525	41567	1385	435

From the overall consumption of the Yazd province, 12% is allocated to automatic, 30% to compressive and 58% to manual brick fabrication workshops. It must be noted that manual furnaces waste a lot of fuel because of their outdated technology. For this reason, their consumption rate is always higher than other two types. Therefore, their environmental pollutions must not be neglected since higher technology will bring about lower pollution rate.

Measurement of pollutants of brick burners of Yazd province:

One of the major environmental problems arising from the activity of brick burners is air pollution as a results of consuming heavy fuels. Pollutant gases produces by combustion process including CO, SO_x and No_x affect their surrounding environment. These gases become a part of the regional air and move by permeability in air flow. Table 4 represents the value of emission of each gases for various furnaces in Yazd – Ardakan road. Particles having diameter more than 30µm are emitted due to bad combustion and injection of excessive mazut to the furnace through sides of manual furnaces. These particles deposit near the furnace. Smaller particles which have lower falling velocity, despite of moving by wind, deposit ultimately on the ground and cover a wider area as a result of divergence of penetration amplitude and emission along with direction normal to the wind.

Leakage of these particles in each density, is one of the obvious and unpleasant inconveniences for people residing near these furnaces. According to field studies in regions near furnaces, even 1km away, deposition of particles as smoky dust can be observed.

Results of experiment on exhaust gases of brick burners are shown in table 5. It must be noted that investigated furnaces are selected randomly from all furnaces of the region and their emitted gases are measured. Moreover, standard values noted in table are derived from regulations and standards of environmental protection organization.

Table 4: quantity of pollutants emission by industrial and manual furnaces in Yazd – Ardakan road in 2010.

Annual (kg)	Monthly (kg)	Daily (kg)	Pollutant
27096300	2258025	75267	SO_X
4729536	394128	13137	NO_X
168912	14076	469	HC
246330	20527	684	CO
1351296	112608	3753	Particles

Table 5: results of experiments on emitted gases of brick burners' chimneys in the studied region.

Suspended particles (mg/m^3)	CxHy ppm) (	NOx (ppm)	H2S (ppm)	SO2 (ppm)	NO2 (ppm)	NO (ppm)	CO (ppm)	Sampling location	Company	City
4/71	8/134	7/14	-	3/78	2/1	5/13	129	Chimney	Jahad Brick	
7/34	1/362	4/27	-	218	¾	1/23	312	Chimney	Kavir Brick	
-	0	7	1	2	1	6	5	Main furnace	Banafsheh	Yazd
-	-	77/515	630	08/173	62/169	15/346	92/5226	Exhaust 1	Dorostkar	
12/34	447	2/135	1/3	3/129	9/5	3/129	437	Main exhaust	Ahrar	
-	-	540	14/451	92/113	09/107	91/432	95/1275	Exhaust 1	Pars	Taft
-	-	63/1220	1845	25/506	13/433	5/787	3150	Exhaust 1	Saman	
7/14	314	3/84	1/0	5/22	3/0	84	291	Furnace 1	Sofalin	
2/62	172	1/63	0	3/19	1/0	63	89	Furnace 1	Khoshrang	Meybod
-	-	185	-	649	0	185	404	Main exhaust	Khosh Naghsh	
6/19	381	3/61	3/0	1/12	3/0	61	325	Furnace 1	Sefid Zar	
-	-	19/333	68/704	6/76	7/141	49/191	94/2984	Chimney 1	Mirhoseini	Ardakan
-	-	86/582	2220	71/385	43/411	43/171	2400	Chimney 1	Marjan No	
-	-	4	0	0	8/0	3	38	Exhaust 1	Shoureh Zar	
-	-	2/233	6/28	0	4/1	8/231	9/1390	Exhaust 1	Derakhshan	Ashkezar
-	-	7	0	0	0	7	219	Exhaust 1	Salar	
-	372	1/28	1/0	2/83	9/3	2/24	220	Furnace 1	Mehr	Bafgh
-	1/483	9/22	3/0	108	4/2	5/20	348	Furnace 1	Jannat	Behabad
-	4/419	5/66	3/0	119	4/3	1/63	311	Furnace 1	Azadi	
-	2/583	4/17	4/0	183	7/2	7/14	497	Furnace 1	Kasra	
-	14	9	1	15	0	9	149	Furnace chimney	Arg	Sadough
-	7/362	5/29	-	286	12	1/28	408	Tall chimney	Mahtab	
300	-	350	18	800	-	-	435			Standard value

Conclusion:

Fuel consumption in brick burners plays the most pivotal role in air pollution in Yazd; so that if in metropolises, the major factor of air pollution are vehicles, in Yazd, the major factor corresponds to brick burners which destabilize the soil by extracting high quality soil for fabrication of brick and tile and consequently, as a result of strong storms in desert regions, soil particles become suspended in the air and intensify the pollution and breathing and lung diseases.

Average consumption of a manual brick burner is 4000 and an industrial unit is 5500 liter per day and overall 9500 liters whose result is emission of 192.5kg SO_X, 1.2kg hydrocarbon, 32.6kg NO_X, 1.75kg CO and 9.6kg particles per day and among them, SO_X have the highest level of emission.

Energy consumption in brick workshops or old Huffman furnaces is 90.2 liters per tons brick and this rate in new tunnel furnaces is 45.1 liters. This means that if we transform old methods into new ones, energy consumption for fabricating each ton of brick will be cut into half.

One of the main and fundamental issues corresponding to brick fabrication processes is improvement and promotion of the energy consumption rate which certainly require optimization and improvement of production processes and application of modern technologies for production with higher quality and efficiency. By optimization of processes, production wastes, energy consumption and adverse environmental effects can be minimized. Consequently, in addition to reduction of production costs and improvement of production quality, a more suitable status can be provided for competition and marketing.

According to real energy consumption rate in each of the factories, the fuel consumption criterion for such factories is determined as much as 80 liters of mazut and $98m^3$ of natural gas. Furthermore, consumption criterion for newly established factories is 55 liters of mazut and $67m^3$ of natural gas. Therefore, it is suggested that factories of the region must survey their energy consumption again and adapt this rate according to the determined limits.

Studies have shown that pollution as a result of bad combustion in manual furnace is the most serious and it will decrease in Huffman and automatic furnaces, respectively. Burners used in manual furnaces do not help forced convection of combustion products and due to incorrect mixture of air and fuel, combustion is done incompletely.

Furnace owners establish their workshops with a low capital and use very cheap mazut. They are not familiar with combustion chambers with engineering design and required facilities for absorbing suspended mazut and moving combustion products away from furnace. Due to proximity of furnaces with residential zones, they are affected by the pollution resulted from factories activity and during night, as a result of temperature reversal, it cannot be tolerated up to 2000m.

A similar research has been performed by the administration of environment of Isfahan province for surveying pollution of 120 brick burners and sand mines located in eastern Isfahan. In this study, production rate of Isfahan province was found to be 10% more than average of national production in pre-revolution period and this increased by 60% in recent years. Furthermore, according to studies, 70% of brick burners of the province are established illegally an in agricultural lands. Consequently, as a result of increase in fuel consumption especially after subsidies organization, a considerable portion of air pollution of Isfahan was due to activity of sand mines and brick burning activities in eastern part of Isfahan.

According to studies performed in the form of comprehensive plan for reduction of air pollution in Kermanshah, the main part of this pollution was found to be due to fuel of vehicles and activity of brick burners ranks after them. In this province, more than 1000 brick burning furnaces are working whose main part as much as 600 furnaces are in Kangavar city. Investigations show that majority of brick burners working around Kermanshah are traditional and use inappropriate fuel; that is, fuel of these furnaces is mazut and resultant gases are CO and SO_2 and NO_x which endanger the health of humans and historical buildings. In this province, to reduce air pollution resulted from activity of brick burners, programs such as plan of replacing fuel and organization and collection of brick burners are taken into account.

Results are consistent with studies noted above and illustrate that brick burners are main contributors to urban pollution as a result of their inappropriate fuel, being old and traditional fabrication process and lack of a pollutant reduction method and it is necessary to implement required measures by corresponding officials and owners of furnaces through setting managerial plan and sufficiently understanding the problem. Since all of the furnaces use mazut as fuel and are mainly manual furnaces which operate in a preliminary manner and high energy losses, if it is possible to replace mazut with natural gas, change in brick fabrication lines and using newer production techniques, or organizing and collecting furnaces in a place far from city, in addition to reduction of air pollution, production costs as well as fuel consumption rate will decrease significantly.

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