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[Research]

Effect of black surfaces to increase the average surface temperature of the earth: A global warning!

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ABSTRACT

Gradual increase of the Earth's surface temperature can cause many significant changes on the climate of our planet. This problem is progressively increasing. One of the main reasons for this phenomenon is the absorption of the Sun's energy and lack of proper reflection of emissions due to man-made activities, one of which is the increase in black surfaces. In this descriptive and cross-sectional research, black surfaces in Gonabad city and the average heat absorption in amount and the increase in average heat absorption due to these surfaces were calculated by physical formula. To date, we used the information obtained from Gonabad Isallobars Office (GIO) and other related offices in the region (from 1980-2009) and performed a simple experiment to support our claim. Many factors were found to be the cause of the increase in average surface temperature of earth, such as increase in black surfaces. These surfaces appear not only on residential buildings but also on roads which have increased (637%) during this 30-year period in Gonabad city. It was calculated that 864 m3 of the air should be replaced to cool 1 m2 of the black surfaces. The average heat of the land surface in desert cities seems to increase rapidly. Therefore, it deserves much attention on the part of local managers and city officials to design plans and make some decisions for reducing or alleviating the problem as soon as possible.

Keywords: *Global Warming, Climate Change, Black Surfaces, Heat Absorption, Gonabad.*

INTRODUCTION

Our planet is faced to a serious problem, as if a patient for whom some symptoms of a disease have appeared; The gradual increase of the Earth surface temperature has caused many significant changes on climate, of which the most important ones are the rainfall reduction and increase of deserts (Byers, 1998). It should be mentioned that understanding the rainfall climate over small but homogenous areas is as important as it is for agriculture and related industries (Murugan, 2008). "With global warming forecast to continue into the foreseeable future, heat waves are very likely to increase in both frequency and intensity. In urban regions, these given future heat waves will be exacerbated by the urban heat island effect and will have the potential to negatively influence the health and welfare of urban residents" (Tan, 2010) (Fig. 1). This factor is a serious threat to destroy all the living organisms or accelerate their migration from dry lands into other areas. Water sources, agriculture, livestock production, pastures, migration, rebellion of pests and disease had already been under the extreme influence of drought (Devisti and Motamed, 2012).

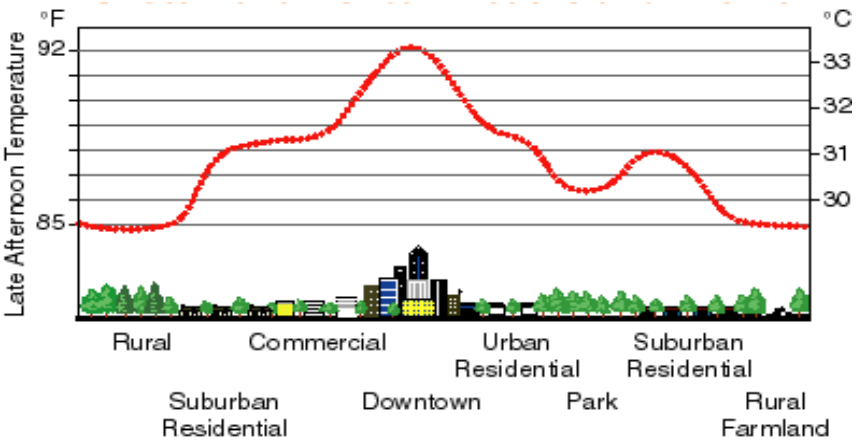

Fig 1. Sketch of an urban heat-island profile (Solecki *et al*., 2004).

Warming along with increasing of greenhouse gases and aerosol concentrations are indicated almost by all kinds of climate models (Murugan *et al*., 2005). Global warming is an average increase in the earth temperature because of many factors such as greenhouse or black surfaces effect as a result of anthropogenic activities. In general, global warming often refers to the warming that can occur as a result of increased emissions of black surfaces trapping the heat from the sun in the earth atmosphere and increase in earth temperature (Dincer, 2000).

Earth is warming drastically compared to natural historical rates of change. Global surface temperatures, nowadays , are over 0.75 °C warmer than those at the beginning of the 20th century and the rates of surface temperature rise have been the greatest in recent decades. 12 of the 13 warmest years in the global surface temperature record have occurred since 1995, and the period 2001 to 2007 has been 0.21 °C warmer than the one from 1991 to 2000 (Hurrell, 2008). Proxy climate series from trees, corals, ice cores, and historical records indicate that we live in the warmest decade of the millennium. The warming of oceans has caused sea water to be expanded and so has contributed to global sea level rise of more than 48 mm since 1993 and 0.17 m over the last century.

Land cover is the physical material at the surface of the earth included water, grass, trees, bare ground, asphalt, etc (Mahdavi, 2010). The increase of land surface temperature is caused by many factors, one of which is increase in black surfaces; however, less information has been reported about the impact of surfaces on increase in the earth heat ; and more has been reported from greenhouse effects resulted from fuel consumption. Increase in black surfaces due to factors such as asphalt with black color, car tires, atmospheric aerosols, fires, cars, clothes, curtains, and anything in which black color is used (Fig. 2).

Furthermore, rainfall reduction and grasslands disappearance or deforestation can increase the earth heat. One of the increasing black surfaces is asphalt which is one of the most significant factors of social and economic indexes in development but it increases daily by both people's building construction projects and government developmental plans. The earth gets its surface heat from the energy of sun and this energy causes the earth surface to become warmer (Sheibani, 2005). Some of this energy is absorbed by soil, water and some other organisms, some remains in the atmosphere and the rest returns to the space (Halliday *et al*., 2001). Black surfaces absorb the sun light more than bright shiny and white surfaces and make the environment warmer (Retallach, 1986).

Fig. 2. Black surfaces caused by fires (The photograph taken by the authors from the fields surrounding Gonabad).

The power of emitting rays of the sun's light is 1400 W/m² before reaching the atmosphere, whose average on earth is 700 W in 12 hours and 350 W/ m² in 24 hours. Since ocean and sea water and the clouds around the earth almost reflect half of the emitted energy of sun , the sun average power output will be almost about 175 W/m² and the estimation of average energy reaching the Earth will be 15.12 MJ/m² per day. It is obvious that the energy which reaches to a surface unit in the equator is more than the mean energy which reaches the earth poles (Kamali and Moradi, 2005).

Climate change is potentially the largest global threat to human health ever encountered. The earth is warming rapidly, due to anthropogenic activities . If current emissions and land use trends continue excessively, the next generations will face more injuries, diseases and deaths because of natural disasters, heat waves, higher rates of climate-related infections, widespread malnutrition, as well as more allergic and air pollution-related morbidity and mortality (Katherine *et al*., 2008).

An analytical research by GIO surveying the climate parameters of the city, located in the south of Khorasan-e-Razavi province and beside the desert in Iran, stated that the mean surface temperature of Gonabad city rose up while rainfall decreased in 2009 in comparison with the last 30 years mean temperature and rainfall (GIO, 2009). It was also pointed out by GIO that the average of the Sun's energy emitted to Gonabad city is 19.99 MJ/m² and is equal to 231 W/m² a figure which is 56 W more than global mean (Moradi, 2006).

Since deserts around Gonabad city are increasing, this study surveyed the increase in black asphalted surfaces in both roads and building roofs, and its consequent effect on heat rise in the city from 1980 to 2009. Some recommendations have also been proposed for reducing or alleviating the problem to save human beings a healthy life.

MATERIALS AND METHODS

This is a retrospective and descriptive cross-sectional research which focused on the earth average temperature in Gonabad city, one of the ancient cities of Iran located in the south of Khorasan-e-Razavi province, about 1091 km far from Tehran (the capital of Iran), and on the margin of desert area with a dry and warm climate. The city was a green land whose name is derived from "Jennat Abad" indicating a place which is full of plants and trees. Gonabad has not only the most number of Qanats (Qanat: a kind of aqueduct) in Iran but also the oldest and the deepest one in the world with 300 m depth (Javan, 2006). Unfortunately, the city with its suburb is growing into a desert which is expanding yearly.

The coordinate of Gonabad is 34° 21′ 10″ N and 58° 41′ 01″ E (Fig. 3). It is about 9715 km² with an annual mean surface temperature about 17 °C and annual average rainfall about 143.1 mm . The city population is about 110000 people. The obtained data were based on the information provided by the GIO, Gonabad Roads Office (GRO), Gonabad Housing Foundation (GHF), and Gonabad Municipality (GM). Black surfaces increase is taken into account mostly based on asphalt available and housing plans in a period of over 30 years (1980–2009). The average rate of heat absorption and its increase resulted from those surfaces in

Gonabad city has been studied using proper physical formula such as $Q=mc\Delta\theta$. where the heat quantity is Q, the mass is m, the specific heat capacity is c, and the final temperature is θ_f while the initial temperature is θ_i (Halliday *et al.*, 2001).

Fig 3. Geographical location of Gonabad city in Iran

To show clearly that black surfaces are effective on the increase of the earth heat, a simple experiment was performed. A FD 100 mm hand lens was used for focusing the sun light on a white circle and black one on a paper (A_4 Bolrox Leader Co, 80 g/m^2) to discover which circle would catch fire sooner. The quite black circle on the paper started burning after 3 seconds of directing the Sun's light but the quite white circle did not burn even after 5 minutes of being exposed to the light (Fig. 4).

The experiment was conducted at 12:00 in 2012-01-16 in a sunny day with a temperature range of 2-9 ^{o}C and a humidity range of 52-89%. This simple experiment confirmed our hypothesis, that is, the black surface absorbs light faster and a greater extent than the white one.

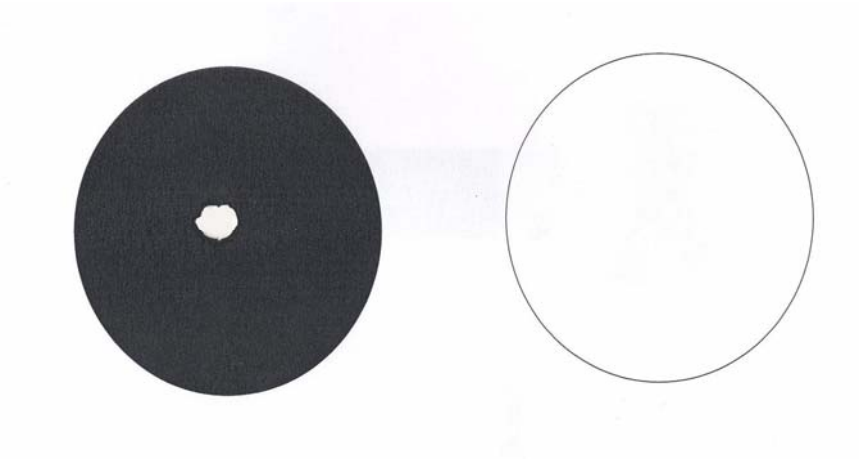

Fig 4. Black and white surfaces potentiality for the sun light absorption.

RESULTS

Roads

The urban roads of Gonabad city were 75 km in length, 7.3 m in width and with 3 m non-asphalted at the both side of the road; it was totally 547500 m² in 1980. However, the urban roads increased to 344 km in length and about 11 m in width with the including of the both sides being asphalted in 2009, resulting in 3784000 m² (GRO, 2009) which showed an increase of 691%. The rural roads being only 5 km long and 5 m wide with covering an area of 25000 m² in total in 1980, increased to 280 km in length and 5.5 m in width in 2009 (GHF, 2009). Altogether, the asphalted area was 1540000 m² with an increase rate of 6160%. The area of urban streets was 348188 m² in 1980, but was 1149377 m² in 2009 (GM, 2009). The sidewalks accounts for one third of the street [33.3%]. The urban streets and sidewalks are not exposed to the sun light during the day light because of buildings and trees shades. Therefore, the shades and sunny surfaces were measured during different days; the exposed surfaces to the sunlight were estimated as 8% instead of 33.3% for sidewalks and 40% instead of 100% for streets. Accordingly, the sum of black surfaces of the streets (348188×0.40) and the sidewalks (348188×0.08) was 167130 m² in Gonabad city in 1980; and if the calculations are performed for the year 2009, we will have 5511700 m² which shows an increase of 3297% (Fig. 5).

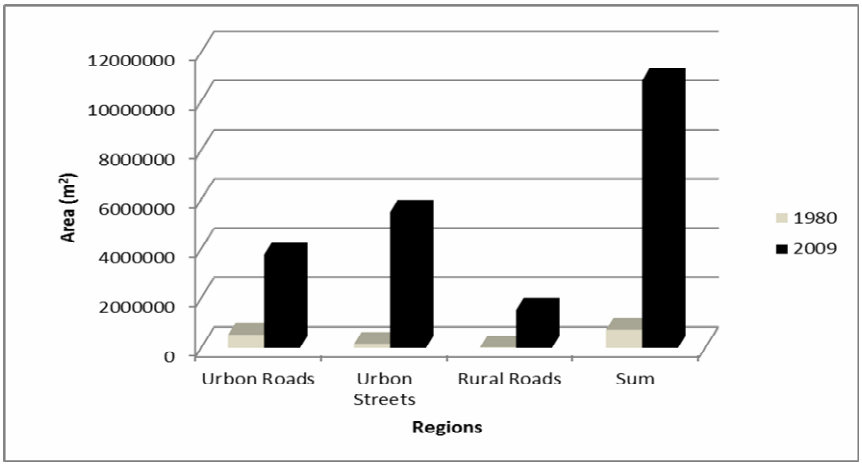

Fig 5. The increase of black surfaces due to roads and streets development plans from 1980-2009.

The residential buildings

The residential buildings and houses in urban areas in Gonabad city have an average space of 250 m² and often with asphalted rooftops. Black surfaces of building yards and black stones on the

walls are also increasing. Considering several measurements and calculations, it was estimated that the average of black surfaces in each building was 195.3 m^2 in 1980, but increased to 210 m^2 in 2009. The number of buildings was 3640 in 1980. Therefore, the sum of black surfaces was 710892 m^2 (3640×195.3) in this year; While the number of buildings was 13008 in 2009 and sum of black
surfaces was 2731680 m^2 (13008×210) with an increase of 384% (GHF, 2009).

The number of rural buildings in 1980 was 14540 and it was estimated that black surfaces was 75 m^2 in average for each building in this year. Thus, the sum of black surfaces of rural residential buildings was 1090500 m^2 (14540×75). Since the number of rural buildings had no increase within 30 years and its black surfaces increased to 180 m^2 in each building during repairs until 2009; therefore, black surfaces increased to 2617200 m^2 (14540×180) with an increase of 240% (Fig. 6).

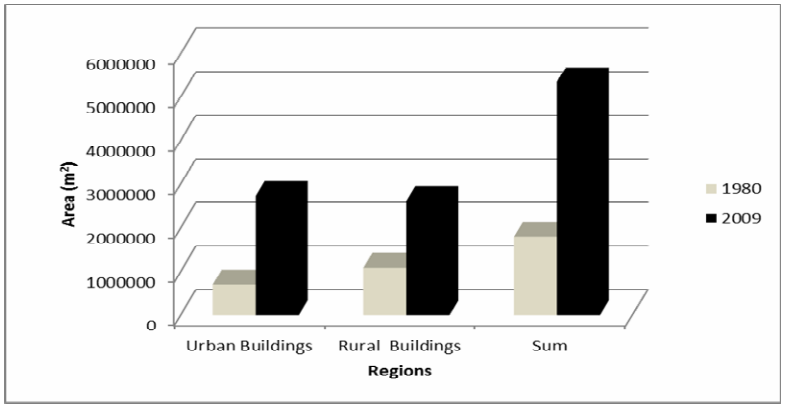

Fig 6. The increase of black surfaces due to buildings development from 1980-2009.

The rural asphalted alleys and the black surfaces belonging to agricultural, industrial, commercial and athletic equipment were not considered in the calculations, and then the following formula was used:
"The sum of black surfaces = rural buildings surfaces + urban buildings surfaces + urban streets and sidewalks surfaces + rural roads + urban roads",
The sum of black surfaces = 1090500+710892+167130+25000+547500 = 2541022 m^2 (in 1980), and
The sum of black surfaces = 2617200+2731680+5511700+1540000+3784000 = 16184580 m^2 (in 2009).
The sum of black surfaces which increased during these 30 years was 13643558 m^2 (16184580-2541022) that points out an increase of 637% which leads to a heat increase of 2.728E14 J (13643558×2E7).

DISCUSSION

Different factors make more opportunities for absorption of the sun light and changing it to heat and can increase average surface temperature including black surfaces. Dark-colored objects absorb more visible radiation; light-colored objects reflect more visible radiation. When the radiation is absorbed by a substance, the atoms in the substance move faster and the substance becomes warm to the touch. The absorbed energy is transformed into heat energy. That is why the tar road (black) is hotter than the mud path beside the road. This heat energy plays an important role in regulating the temperature of earth crust, surface waters, and lower atmosphere (Kordavani, 1997). The trees leaves, even in a dry form, can reflect the Sun light in visible spectrum and can also be as insulator for the earth against heat which prevents the land waters from vaporizing. Rainfall reduction can destroy plants and remove the insulator layer, so the sun energy will be changed to a harmful heat. Some factors such as surface materials, surface asphalt, asphaltic roofing and water can increase the urban surface temperature (James *et al.* 1986). In contrast, Shashua-Bara *et al*. (2009) concluded that planting trees or creating parks or green roofs decrease the

air temperature of an urban area. The heat flow at the Earth's surface varies remarkably with urban development (Ojimaa and Moriyama, 1982). The air temperature within parks and beneath the trees was broadly supportive that green sites can be cooler than non-green sites (Bowler *et al*., 2010).

As the air density is 1.4 kg/m^3 and its special heat capacity is 1006 J/kg °C, if we tend to raise the temperature of 1 m^3 of the air from 10 °C to 35 °C, based on the heat calculation formula:

So, 35210 J of heat is essential (1.4×1006×25). If the absorbed heat by 1 m^2 of the black surface is 20 MJ/m^2/day, then 1 m^2 of the black surface can increase 864 m^3 of the air up to 25 °C warmer (20×10^6/35210). This means that 864 m^3 of the air should be replaced to cool 1 m^2 of black surfaces. Therefore, if the increased black surfaces in Gonabad city are intended to be cool as much as 10°C, then 19.37E9 m^3 of the air (2.728E14/14084) should be replaced.

Although the researchers did their best, some other black surfaces contributing to the increase of heat could not be taken into consideration. A few of these factors may include tires mostly used in automobiles (Yamashita and Yamanaka, 2013 ,), dust and mist because of wind and rubbers friction, soot particles, big fires on residential buildings, industrial areas, and farmlands. Using black colors in automobiles, clothes and curtains is of less importance, however some energy is needed to cool the heat resulted from the black colors.

CONCLUSION

At present, with daily increase of black surfaces, the sun energy absorption and then the land heat are increasing. In cities adjacent to the deserts, the average temperature of the earth surface is increasing annually and if it continues in this way, probably people will leave these cities. Then it seems necessary to find a way to get rid of the problem. Also, it is a warning for the city officials to take proper actions against it as the majority of the scientists agree that global warming is one of the most serious threats to humanity. The human being may face to more problems in the future, a fact which will be inevitable. Some steps must be taken by people and the authorities for preventing the extreme increase of the earth surface heat. These measures should include continuous trainings for more protection of living environment, using white and bright shiny colors instead of black ones, reducing soot, preventing further desertification, protecting grasslands, and considering clouds fertility plans.

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REFERENCES

Bowler, E. D., Buyung-Ali L., Knight T. M., Pullin S. A. (2010) Urban greening to cool towns and cities: A systematic review of the empirical evidence, Review Article. *Landscape Urban Planning* 97(3): 147-155.

Byers, R. (1998) *General Meteorology*. 1st ed. Translated by: Tajeddin Banihashem, Behrouz Hajebi and Reza Behroozian. Iran, Tehran: Academic Publishing Center [In Persian]

Devisti H., Motamed M. K. (2012) Environmental and socio-economic impacts of drought from the viewpoint of Guilan paddy farmers, north Iran. *Caspian Journal of Environmental Sciences* 10(2): 227-235.

Dincer, I. (2000) Is it Global Warming or Global Warning? *International Journal of Global Warming*. Canada, University of Ontario: 1-4.

Gonabad Housing Foundation (2009) *Annual reports and statistics*. Gonabad, Khorasan Razavi, , Iran. [In Persian]

Gonabad Isallobars' Office (2009) Annual reports and statistics. Gonabad, , Khorasan Razavi,, Iran. [In Persian]

Gonabad Roads Office (2009) Annual reports and statistics. Gonabad, Khorasan Razavi, Iran. [In Persian]

Gonabad Municipality (2009) Annual reports and statistics. Gonabad, Khorasan Razavi, Iran. [In Persian]

Halliday, D., Resnick, R., Kenneth, K. S. (2001) *Physics*. Vol 1. John Wiley & Sons.

Hurrell, J. W. (2008) A changing context for life on Earth. *Journal of Allergy Clinical Immunology* 122(3): 473-474. DOI:10.1016/j.jaci.2008.07.017.

James, A., Henry, E., Steven, E., Dicks, S. (1986) Association of urban temperatures with land use and surface materials. *Lands Urban Plan* 14: 21-29.

Javan, A., Hassanli A. M., Shahrokhnia M. A. (2006) The ancient qanat of Iran. Proceeding of 1st IWA international symposium on water and wastewater technologies, Iraklio, Greece. 28-30 Oct.

Kamali, Gh., Moradi, I. (2005) Solar radiation, principles and applications. Iran, Mashhad: Ferdowsi university press. [In Persian]

Katherine, S. M., Robert, T., Truckner, R., Weber, W. R., David, B., Peden, D. (2008) Climate change and allergic disease. *Journal of Allergy and Clinical Immunology* 122(3): 443-453. Kordavani, P. (1997*) Meadows, problems and solutions in Iran,* Tehran: Tehran university press. [In Persian]

Mahdavi, A. (2010) IRS-1C image data applications for land use/land cover mapping in Zagros region, Case study: Ilam watershed, West of Iran. Caspian *Journal of Environmental Sciences* 8(1): 35-41.

Moradi, I. (2006) *Solar radiation principles and applications*., Institute of Mashhad University Press, Mashhad, Iran. [In Persian]

Murugan, M., Mukund V., Ramesh, R., Hiremath, M. B., Josephrajkumar A., Shetty, P. K. (2008) Centennial rainfall variation in semi arid and tropical humid environments in the cardamom hill slopes, southern Western Ghats, India. *Caspian Journal of Environmental Sciences* 6(1): 31-39.

Murugan, M., Shetty, P. K., Hiremath, M. B. (2005) Atmospheric warming induced changes in future rainfall and Implications on water and agriculture in India. *Caspian Journal of Environmental Sciences* 3(2): 132-141.

Ojimaa, T., Moriyama, M. (1982) Earth surface heat balance changes caused by urbanization. *Energy and Buildings* 4(2): 99-114.

Retallach, B. J. (1986) *The physical meteorology.* 1st ed. Translated by: Alireza Sadeghi. Iran,Tehran: Markaz nashre daneshgahi. [In Persian]

Shashua-Bara, L., Pearlmuttera, D., Erell, E. (2009) The cooling efficiency of urban landscape strategies in a hot dry climate. *Lands Urban Planning* 92(3-4): 179-186.

Sheibani, D. (2005) Survey and analyzing of Gonabad city weather conditions, Annual reports, Gonabad, Iran. [In Persian]

Solecki, D. W., Rosenzweig, C., Pope, G., Chopping, M., Goldberg, R., Polissar, A. (2004) *Urban Heat Island and Climate Change: An assessment of interacting and possible adaptations in the Camden,* New Jersey region. New Jersey's Environmental Decision Making. Available from: http://www.state.nj.us/dep/dsr/research/urbanheat.pdf.

Tan, J. (2010) The urban heat island and its impact on heat waves and human health in Shanghai. *International Journal of Biometeorology* 54(1): 75-84.

The Ministry of Building and Roads (2009) Meteorological organization of I.R. of Iran. Gonabad, Khorasan-e-Razavi, iran. Available from: www.mrud.ir.

Yamashita, M., Yamanaka, Sh. (2013) Dust Resulting from Tire Wear and the Risk of Health Hazards. *Journal of Environmental Protection* 4: 509-515.

بررسی تاثیرسطوح سیاه بر افزایش متوسط گرمای سطح زمین: یک هشدار جهانی

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(تاریخ دریافت: ۹۱/۱/۲۷ - تاریخ پذیرش: ۹۱/۵/۲۰)

چکیده

افزایش تدریجی گرمای سطح زمین می تواند باعث تغییرات شگرفی درآب و هوای سیاره ما، زمین، شود. این مشکل به طور مدام در حال فزونی است. یکی از علل عمده این پدیده جذب انرژی خورشید و فقدان انعکاس مناسب پرتوهای خورشیدی، به دلیل فعالیت های انسان است که یکی از آن ها افزایش سطوح سیاه و یا تیره است. در این مطالعه توصیفی ومقطعی سطوح سیاه در شهر گناباد- ایران و میزان جذب گرمای متوسط و مقدار افزایش آن بر اثر این سطوح بر اساس فرمول های فیزیکی مورد محاسبه قرار گرفت. ما برای انجام این بررسی از اطلاعات اخذ شده از اداره هواشناسی شهرستان گناباد و سایر ادارات مرتبط منطقه (از ۱۳۵۷ تا ۱۳۸۷) استفاده کردیم وهمچنین آزمایش ساده ای را برای اثبات این ادعا به انجام رساندیم. سطوح سیاه در ساختمان های مسکونی و نیز در جاده ها وجود دارند که ۶۳ درصد در طول این ۳۰ سال در شهرستان گناباد رشد داشته اند. در این بررسی برآورد شده است که ۸۶۴ متر مکعب هوا می بایست برای خنک کردن ۱ متر مربع سطح سیاه جا به جا شود. به نظر می رسد گرمای متوسط سطح زمین در شهرهای کویری با سرعت بیشتری افزایش می یابد. لذا توجه و دقت بیشتر مسئولین، مدیرا ن و مقامات مسئول محلی برای طرح برنامه های اجرایی و عملی و اتخاذ تصمیماتی استراتژیک و عملیاتی برای کاهش وتسکین این مشکل به سرعت ممکن لازم و ضروری به نظر می رسد.

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