The Influence Of Urban Planning And Building Factors On The Dustiness Of The Urban Environment

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Abstract. Authors define dust content of the urban environment as presence at air of particles of dust and dusting of vertical and horizontal active surfaces by them because of their sedimentation. Urban-planning organization of building and its parameters have significant effect on dust content of the urban environment. Manifestation of local wind-blown dust in the territory of residential construction is promoted by planning structure of the city, functional zonings of its territory, type of residential construction, orientation and mutually placement of buildings, density of building and its number of storeys, trace of drives and pedestrian ways, the principles of placement and type of green plantings. In the conditions of urban development the main means of decrease in dust content are actions for improvement of microclimate of the urban inhabited environment, thanks to selection of the range, Designs and mutually placements of green plantings concerning building, taking into account relief and climatic conditions of the territory; to flood of the territory, organization of watering water supply system, overhead irrigation of trees and paving; to the paving device with existence of infiltration joints. When forming and updating residential construction for decrease in dust content of the environment it is necessary to use the construction reception consisting in use of front finishing materials with low degree of dust deposits and high ability of self-cleaning under the influence of natural and artificial sprinkling.

1.Introduction

Dust in air of city leads to physical contamination of various urban surfaces, loss of their esthetic attractiveness and decrease in albedo and increase in overheat, to formation of the favorable environment for development of bio-pollution. Dusty air negatively influences health of the person, toxically affects plants, contaminating and reduces their hygienic effect. Dust abatement of the urban environment is urgent task for the majority of the cities as in the urbanized territories presence of dust at air can be designated by both natural, and techno genic factors.

2. Main part

Dust content of the urban environment in many respects depends from urban planning organization of building and its parameters.

Authors allocate the following urban-planning and planning factors exerting impact on dust content of the urban environment:

1. Planning structure of the city. Radial and radial - ring systems of the cities possess the best indicators of resistance of planning structure of the city to dusty air influence. Alternation of green rings with inhabited territories, existence of green wedges in structure of the city and boulevards promotes effective cleaning of the air streams arriving from suburban and industrial territories and prevents penetration of dust is interfered into by dwelling zone. Existence of water objects in system

of the city supports favorable microclimate of the urban environment, heat moisture conditions of the territory and respectively reduces dust content factor. According to O. A. Filatov [1] researches, the sanifying action of water object is defined on city microclimate by influence zone which makes for the built-up territories from 700 m (summer) to 1420 m (spring). On the built-up territory within zone, there is fall of temperature of air on 2-7 ^{0}C and increase in humidity for 8-15%.

Efficiency of influence of water object on microclimate of the city depends on that, placement of functional zones of the city concerning reservoir is how rationally solved. For example, the city of Volgograd with characteristic linear planning structure is unsuccessful on dust content factor. The territory of Volgograd, 90 km long, has access to the river only in territories with a general extent of 30 km. Other coastal territory is busy with industrial and utility and warehouse facilities.

Orientation of longitudinal city mains from the North on the South, promotes formation of symmetric flow of the air caused by thermal conditions of the city. Therefore, the trunk mains of Volgograd located in parallel concerning the river are peculiar corridors for intake of dust to the city and its transit through planning areas at light breeze or full calm [2].

It should be noted that on the streets oriented from the West to the East in the afternoon the roofs turned on the South most strongly heat up. There is air circulation and wind-blown dust from shady side of the street to sunnier side, own air circulation over roofs is created.

In the central part of the city the ascending air currents more intensively because there temperature is higher, than on its suburbs that determines wind direction at earth surface to the downtown and transfer by scant wind of dust there. At night sedimentation of dust on surface of the central part of the city as a part of which residential construction is placed takes place.

Efficiency of dedusting of wind flows at the expense of the organization of continuous system of barriers shows to wind in the form of building and gardening experience of town planning of Central Asia and Kazakhstan. From prevailing winds, creation of step profile of building, with gradual accumulation of number of storeys to the center, promotes wind-blown dust over the city with the minimum dust deposits [3, 4].

Partitioning of open-spaces, big by the sizes, landings of green plantings and beautification features interferes with dust formation on the urban area. The maximum rupture of open-spaces, according to V. A. Karamyshev, should not exceed 8-10 heights of building [3]. According to recommendations of TsNIIP of town planning [5], the maximum areas of the intermain territories have to be limited to 70-80 hectares, at the same time density of highways will make not less than 2,3-2,5 km/sq.km.

2. Functional zoning of the territory. For regulation of the wind mode in building and protection against pulverulent reduction of the free vacant territories considered as sources of local dusting burtrebutsya.

Content anthropogenic dust of the urban environment origin can be as a result of the insufficient accounting of the prevailing directions and wind velocities at design of the industrial enterprises, their reconstruction or transfer into release of new products.

Territories, adjacent to city thoroughfares, are under the influence of the anthropogenic dust considerably worsening quality of life of citizens. Reduction of number of parking places of open parkings on the territories adjacent to highways, depending on intensity of the movement, considerably reduces dust content of the environment by 15-50% of normative size.

3. Building type, orientation and mutually placement of buildings. The wind mode of building and its dust content in lower storey of the atmosphere are influenced by geometrical parameters of building (width and height of buildings), and relative positioning of domestic buildings from each other.

Depending on building type the turbulent flows of air, forming in the level of buildings can have the variations. Transitional sites between zones of wind shadows and the increased speed should be considered as the most dusty. Here dust and long time can be late to remain near area of turbulence, getting then to the building through stitched openings. Besides, I. K. Lifanov, V. A. Gutnikov and A. S. Skotchenko [6] pilot studies showed that even in the conditions of good windswept of the territory among group of buildings there can be quiescent areas where dust is deposits and accumulates. Buildings, being located, from each other, create internal spaces of different configuration with the

different wind-blown dust. As A. A. Shreyber [7] specifies, the perimeter closed and partial closed domestic spaces which are characterized by coefficient of space isolation from 1 to 0,8 are the least windswept. At the perimeter density in the range from 0,7 to 0,32 (all types of the organization of domestic spaces, except of the buildings on the perimeter and partial closed) the average speed of airflow makes up to 80% of wind velocity out of building.

The significant effect on character of air currents in building and on the size of pollution is rendered by gaps between buildings on yard contour if wind direction matches axis of gap or is at an acute angle to it. The probability of manifestation of superficial dust formation significantly increases if the distance between opposite standing buildings located facades to prevailing wind direction and creating domestic space exceeds 3-4 • H. As the reason for that, serves exceeding of distance between buildings of depth of zone of optimum speeds behind the building with the highest wind load. If two in parallel standing buildings are located with long axis in the direction to prevailing winds between which gap from 1 to 4 • N, it is possible to expect emergence of the centers of dust formation as a result of strengthening of wind velocity in the territory of the yard [8].

The recommended area of the domestic territory on which the most optimum wind mode forms makes from 0,35 hectares (for 5-storey building) to 1,4 hectares (for 9-12-storey building). The most admissible area of the yard it is necessary to accept 1,8 hectares. The closed and half-closed domestic spaces taking into account requirements protection from wind, dust and sun are recommended to be accepted the size 4-6Hx4-6H [5, 9]. The space and planning module of building is of great importance for formation of favorable wind-blown dust conditions in the territory of the urban inhabited environment.

Important indicator is orientation of buildings, which promotes emergence of wall convective flows. In the southern cities of wall, turned on the West and the southwest, test high intensity of radiation, in combination with high daytime temperatures of air. Therefore, walls of such orientation have convective flows capable to kick up dust from the surface of the territory, even in the period of wind calm [10].

The insufficient accounting of speed and the direction of prevailing winds in the territory of residential construction becomes the reason of continuous wind dust impact on entrances to buildings. For example, in Volgograd (the area Spartanovka and Seven winds) in residential construction of 9 floors above, the powerful wind flows lifting significant amount of dust in air are observed. Especially wind dust influence is shown at the buildings of free design creating intra domestic spaces of the big area. Strengthening of wind is promoted by existence of arches and apertures at buildings of big extent.

4. Density of building and its number of storeys. Now process of active consolidation of inhabited spaces due to demolition of the invaluable building which is in territories with high town-planning value is observed. Inclusion of new constructions in the existing building often leads to deformation of the wind mode of the territory and formation of zones of turbulences. Here it is formed local wind-blown dust or the stagnant areas steady in time and promoting dust in the environment.

Number of storeys of building has significant effect on conditions of windswept and stagnant of the territory. At joint placement of high buildings (more than 15 floors) the ascending wind flows at the expense of turbulent and convective airflows kick up dust and garbage from earth surface and abandon them on upper floors [6].

5. Trace of pedestrian ways. The pedestrian ways located at an angle to the direction of prevailing wind less than $40\text{-}50^0$ can be under negative impact of local wind-blown dust in the territory of the city inhabited environment [2]. In the conditions of high probability formed dust it is necessary to place the main carriageways and pedestrian ways perpendicular to wind direction and to combine them with shelterbelts.

6. Placement of green plantings in the territory of urban development. Green plantings in structure of the city are the most important means of regulation of the wind mode in its territory and prevention of emergence of superficial dust formation. So, for example, on the site with bush, at the height up to 2 m, there is wind reduction of speed twice [11]. The amount of dust absorbed by one hectare of woody

plants in combination with lawns by different estimates fluctuates depending on pedigree structure and age of trees from 32,0 to 72,0 tons per year. It indicates high performance of plants of dedusting of the dusty flows getting on the territory of building.

Efficiency of decrease in dust content of the urban environment green plantings can be insufficient owing to arrangement of streets in structure of the city without relief and orientation that influences formation of the adverse aeration and heat moist modes, and as a result leads to creating favorable conditions for emergence of superficial wind-blown dust.

It is important to bring selection of the range of wood and shrubby vegetation taking into account features of plants remove out of the city atmosphere dust and to dispose it by means of rainfall or watering, table 1. Lack of level gardening in territories adjacent to highways territories leads to decrease in absorption of dust bushes and foliage of high trees in general.

Table 1. Ability of trees to detain dust and to self-clean [12].

Name Trees	The Srednezapylennost, g/m2		It is washed away by rain, %
	Till the rain	After rain	
Elm	3,3910	0,0151	81,9
Teil (Tilia)	1,3202	0,3912	70,4
Maple (Aser)	1,0597	0,2743	74,2
Poplar (Populus)	0,5516	0,1342	75,5

Openwork designs of landings possess the best protective properties against dust and wind. Change of wind velocity under the influence of landing of openwork design happens smoothly and gradually, autoregulation of wind flow and its effective dedusting is carried out.

7. Improvement of inhabited territories. Low level of improvement of inhabited territories leads to increase in incidence of the children's population by 1,5 times, than in the well-planned yards [13]. Of territories of low level of improvement, it is characteristic: application of asphalt and concrete surfaces, the organization of fast drain of water, the drainage leading to decrease in water accumulation coverings and soil and to strengthening of dust content of the urban environment.

At improvement of the inhabited territory, the main attention has to be paid to reduction of the area of open soil surfaces and asphalt coverings. It is necessary to consider that coverings of different roughness at the height up to 2 m are capable to change wind velocity in the territory of building. Application of asphalt concrete covering leads to increase in wind velocity from 4 m/s to 5,6 m/s [11].

Flood of the territory of the urban inhabited environment, especially in droughty climatic zones, has special value for reduction of dust content of the environment. The device of fountains reduces air temperature 1,5 -5^{0}C and increases relative humidity for 6-10% that has significant effect for prevention of superficial dust formation. Preservation of rainwater by means of ecologically justified vertical layout where the necessary amount of atmospheric water remains in the territory is important, but it is not taken away in collectors.

Authors believe that application of construction receptions also allows reducing dust content of the urban environment. In case of the directed wind-blown dust impact directly on the building in general or on its parties separately, the effective remedy should be considered use of designs of the houses having high dust-protection properties. In the conditions of reconstruction of residential construction important issue in aspect of dust content of the environment it is necessary to consider use of front finishing materials with low degree of to detain dust and high ability of self-cleaning under the influence of natural and artificial sprinkling [14].

Conclusions. As the most effective remedies of decrease in dust content, according to authors, it is necessary to use the following urban - planning and planning and construction methods:

1) The device of green rings, wedges and boulevards in structure of the city as effective remedies of dedusting of airflows; mutually placement of functional zones and water objects, existence of open corridors in coastal area, for receipt in building of the sanifying airflows. Placement new,

reconstruction of existing industrial facilities rather adverse wind directions in aspect of dust content. Reduction of the empty territories in system of the city.

2) Trace of city highways concerning parts of the world, reduction of open parking in territories adjacent to highways territories for 15-50%. Arrangement of pedestrian ways perpendicularly or at an angle not less than $40\text{-}50^0$ to the direction of prevailing wind.

3) Creation of step profile of building, with gradual accumulation of number of storeys to the center and the minimum detention of ground wind-blown dust. Avoidance of joint arrangement of large number (5 and more) high-rise buildings (more than 15 floors) that reduces activity of the ascending wind flows, and you mean dust content in the level of upper floors of buildings.

4) Providing rupture of open-spaces – no more than 8-10 • H preventing dust formation is not higher than the area of the between highways 70-80 hectares, with density of highways not less than 2,3 -2,5 km/sq.km.

5) The organization of the steadiest against wind-blown dust influence perimeter closed and partial closed domestic spaces (coefficient of space isolation from 1 to 0,8). Elimination of gaps between buildings on yard contour at coincidence of wind direction to axis of gap or existence of acute angle.

6) Formation of domestic spaces with the space and planning module no more 4-6nkh4-6H, from 0,35 hectares with an optimum area of intra domestic territory (for 5-storey building) to 1,4 hectares (for 9-12-storey building), the most admissible 1,8 hectares. The emphasis on construction of complex constructions of inhabited and public appointment is necessary.

7) The choice of finishing building timbers with low degree of to detain dust and high ability of self-cleaning under the influence of natural rainfall and cleaning measures.

In the conditions of building reconstruction the main means of decrease in dust content the receptions directed to improvement of microclimate of the urban inhabited environment:

- gardening of the territory with the correct selection of the range and design of landing;
- the flood of the urban environment at the expense of the device of fountains, the organization of watering water supply system, overhead irrigation of trees, reducing dust content of the environment and preventing superficial dust formation;
- the paving with existence of infiltration joints or the creation of surfaces by means of the artificial or natural not raising dust, but draining materials allowing to reach withdrawal of surface waters directly in soil and to improve heat moisture conditions of the territory.

References

[1] Filatov O A *Features of the temperature and moist and wind mode of building of the coastal territory (on the example of Volgograd).* Thesis for degree of candidate of technical sciences M . p. 25

[2] Stetsenko S E 2006 *The accounting of factor of dust content in formation of urban development*. Thesis for degree of candidate of technical sciences on special 18.00.04, 25.00.36//MGSU. P. 223

[3] Karamyshev V A 1975 *The city is under construction in the desert* . Alma-Ata: Kazakhstan p. 128

[4] Melnikova L N 1992 *Aeration of the cities of arid zone of Central Asia*. Survey information "Environmental issues of architecture and town planning". issue 1. M. p. 23.

[5] 1980 *Recommendations about the accounting of climatic factors in design, building and improvement of the cities and group systems of the inhabited places*. M. TsNIIP of town planning, p. 140.

[6] Lifanov I K Gutnikov V A Skotchenko A S 1998 *Modeling of aeration in the city*. M. Dialogue MSU p. 134.

[7] Shreyber A A Karmadonova N Yu April-June, 2001 *The accounting of additional pollution sources of free air at the organization of inhabited territories* "The pure city", No. 2(14)

[8] Semashko K I 1978 *Assessment of the wind mode of residential construction and its regulation by architectural and planning means*. The thesis on соиск. to. so-called. M.

[9] Karamyshev V A Syrmolotov V V 1984 *Increase in compactness of public building of inhabited residential districts in the conditions of continental deserts and semi-deserts of moderate belt*.Architecture and construction. №5. p.15.
[10] Stetsenko S E 2013 *Characteristic of dust as environment pollution source*. Materials XI of the international scientific conference "Quality of Internal Air and Environment" pp. 59-63
[11] 1990 *Technique of complex assessment of the environment at design of residential areas and residential districts*. M. TsNIIP of town planning. p. 55.
[12] 2000 *Seminar materials "Methodology of assessment and management of risk among the specialists working in the field of environmental management"*, the Agency of the international development of the USA, Institute of stable communities of the USA
[13] Sidorenko V F 2000 *Theoretical and methodological bases of ecological building: Monograph*. VOLGGASA. Volgograd p. 200.
[14] Stetsenko S E Sidorenko of V F 2014 *Issledovaniye of roughness and surfaces of front building timbers*. Materials of the international scientific and technical conference "Engineering-ecological Problems of Construction Complex of the Region" Volgograd. pp. 196-200.