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Radon Risk Assessment for Urban Planning and GIS Data Processing

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ABSTRACT

Natural sources of radiation is a big part of the total radiation exposure that humans receive in their lifetime. The majority of this natural radiation is harmless to humans in the ambient environment. However, radon, a large component of the natural radiation that humans are exposed to (greater than sixty percent), can pose a threat to the public health when radon gas accumulates in poorly ventilated residential and workplaces spaces. According to the World Health Organization: “Indoor radon gas is a serious health problem that can be better addressed by spreading right informations through local Authorities to motivate individuals to fix their homes. Millions of homes in the world are infact estimated to have elevated radon levels. Fortunately, the solution to this problem is quite simple. As well as the hazards from smoking, the health risks of radon can be reduced.” In this paper we report the activities of Municipality of Pomezia, a medium size Town near Rome Italy. To cope with local Radon risk the local administration have created a Radon Front office supplying radon passive detectors free of charge to families to map the risk. Resulting data are then plotted through an open source Geographical Information System to help Urban planners and regulators to reduce the risk.

Keywords: indoor radon, radon hazard, radon risk, soil radon, intrinsic permeability, urban planning.

Radon Help Desk

The Municipal Administration of Pomezia promoted an awareness and information campaign on the human health risks caused by exposure to Radon gas, giving interested citizens the possibility to detect the presence of radon gas directly in their homes.

A Radon Help Desk was opened from 19 November 2015 until 16 June 2016 and 573 kits were delivered to 430 families (in some cases two kits were provided for homes on more than one floor). 302 of these kits were returned, i.e. a return percentage of 52.7% which was lower than expected, given the subject matter, but in line with other surveys of this type conducted on a voluntary basis.

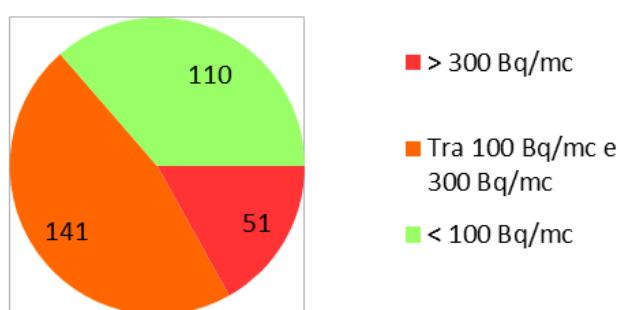
Annex 1 shows the return data used for drawing up the GIS maps (anonymized for privacy reasons).

Table 1. Statistics on Delivered and Returned Dosimeters

| GIS Statistica Data | | |
|---------------------------------------|------------|-----|
| Rn Conc. | Houses No. | |
| > 300 Bq/mc | 51 | 17% |
| 100 Bq/mc - 300 Bq/mc | 141 | 47% |
| < 100 Bq/mc | 110 | 36% |
| | | |
| Total number of dosimeters analized | 302 | |
| Total naumber of dosimeters delivered | 573 | |
| Return percentage | 52,7% | |
| | | |
| Max Value | 1875 | |
| Min Value | 10 | |

Overall, only 36% of homes monitored resulted free from Radon Gas contamination whereas 64% required attention.

Table 2. Statistics on Detected Indoor Concentrations - Number of Survey Points



Risk classes were attributed according to the latest WHO and Euratom Agency indications which establish an absence of risk for up to 100 Bq/m³ of indoor Radon and a limit of 300 Bq/m³. Consequently, values of between 100 - 300 Bq/m³ were considered medium risk and above 300 Bq/m³ were considered high risk.

Correlations between Geology, Soil Radon and Indoor Radon

In order to assess any possible correlation with the local geology, taking into account the previous experience of ISPRA (Italian Institute for Environmental Protection and Research) in the PERS project (Potential Emanation of Radon from the Soil), the simplified geological map of outcropping lithotypes was drawn up based on existing maps.

The geological layer was therefore compared against the Soil Radon and Indoor radon, showing a clear direct correlation with the lithology, except for evident anomalies in the coastal area and in the north-west part of the Municipal territory. These anomalies could be explained by faults and lines of structural weakness which are more plausible in the NW part of the territory but are not reported in the coastal area.

Soil Radon and Indoor Radon, on the other hand, show a clear correlation in those areas covered by indoor measurements.

The fundamental variable limiting the validity of indoor radon for the purpose of territorial planning, in addition to the inevitable variability of how buildings are constructed and maintained (by no means a trivial aspect), is the limited area of coverage in the investigated territory. The measurements are in fact linked to the presence of existing homes, consequently there is no way of acquiring useful information to cover the study area in agricultural, artisanal and industrial areas.

This limitation is evident in this study for the zone of Via Laurentina and intersecting roads; on the Indoor Radon map the area presents a medium risk zone while the Soil Radon map highlights a "Critical" Risk.

In fact, there is an industrial area in this zone and it was not possible to acquire any Indoor Radon data through the Radon Help Desk campaign.

It is clear, therefore, that the approach given in the publication of the protocol for territorial planning published in 2012¹ by the writer et al., is in full agreement with the results emerging from this study.

Correct Radon risk planning is therefore essentially carried out by surveying Soil Radon to which Indoor Radon results can provide useful additional knowledge. On the other hand, knowledge of indoor radon represents a fundamental step for assessing the population's exposure to radon. These two aspects therefore have different purposes and must contribute to a better and in-depth knowledge of the territory and the risk to which the population is exposed.

The use of GIS, i.e. the territorial information system, was then extended through the free download and implementation of the open source maps of OpenStreetMap.

The layer of roads and squares in the municipal area has therefore been usefully exploited to allow for targeted queries on urbanized and non-urbanized areas of the territory. In fact, by means of a simple query it is possible to identify the study result for a single road. If this tool were made available to the public, it would make an initial area risk assessment possible for any individual. The system also lends itself to use on the web as well as locally.

Statistical Analysis of the Collected Data

On the basis of the classes defined in the previous paragraph, the acquired data was then processed using contouring software with a kriging algorithm.

¹ Italian journal of engineering geology and environment - Classification of radon hazard in urban planning focused on risk management - December 2012.

Cartography analysis processed in this manner was then performed in a territorial information system based on the open source platforms GvSig and Qgis in order to allow the visualization of the data in cartographic format and available in the graphic drawings accompanying this study.

Below, on the other hand, is the numerical statistical data processed through the spatial intersections made possible by the GeoProcessing tools available in the aforementioned software. First of all, after setting the spatial coordinates for each measurement point, perimeters were drawn around the districts and their surface areas were then calculated.

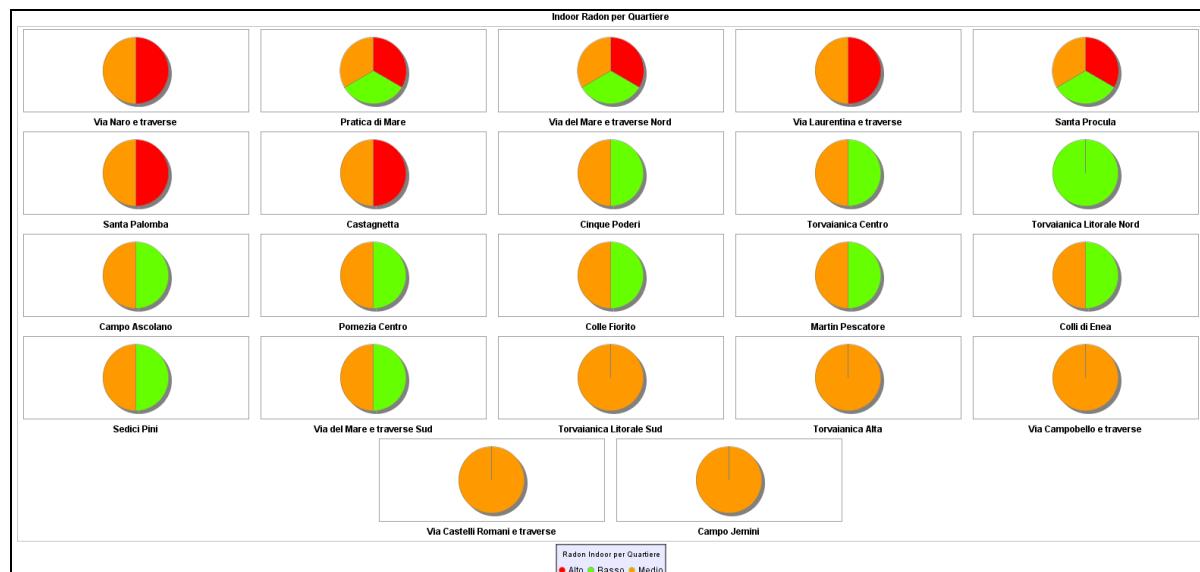
| District | Code | Area Sq/m | |
|--------------------------------|---|-----------|----------------|
| Castagnetta | C6 | 2656892 | |
| Torvaianica Centro | B1 | 616885 | |
| Torvaianica Litorale Nord | B2 | 641038 | |
| Campo Ascolano | C1 | 895464 | |
| Torvaianica Litorale Sud | B2 | 409456 | |
| Torvaianica Alta | C3 | 477977 | |
| Pomezia Centro | A | 1799607 | |
| Via Campobello e traverse | D3 | 381473 | |
| Via Naro e traverse | D2 | 1419851 | |
| Via Castelli Romani e traverse | D6 | 1031941 | |
| Via Campobello e traverse | D3 | 3112541 | |
| Via Laurentina e traverse | D4 | 6120910 | |
| Pratica di Mare | E | 6966601 | |
| Colle Fiorito | C5 | 198002 | |
| Santa Procula | C8 | 5826932 | |
| Cinque Poderi | C7 | 1353673 | |
| Martin Pescatore | C2 | 1016185 | |
| Santa Palomba | D1 | 4288746 | |
| Campo Jemini | C4 | 719196 | |
| Colli di Enea | D8 | 371206 | |
| Sedici Pini | D7 | 486006 | |
| Via del Mare e traverse Nord | D5 | 1415744 | |
| Via del Mare e traverse Sud | D5 | 540772 | |
| | District total Surface | 42747099 | m ² |
| | Municipal surface | 86832818 | m ² |
| | Percentage of total municipal surface in District | 49 | % |

Furthermore, by intersecting the layers, the risk classes were detected according to the following table:

| Radon Indoor per Quartiere | | | | | |
|----------------------------|-------------------|---------------|---------------------------|-------|----------------|
| Code | District AREA sqm | Risk Area sqm | District | Risk | % Area at Risk |
| A | 1799607 | 640396 | Pomezia Centro | Basso | 35.59% |
| A | 1799607 | 1159211 | | Medio | 64.41% |
| B1 | 616885 | 26843 | Torvaianica Centro | Basso | 4.35% |
| B1 | 616885 | 590041 | | Medio | 95.65% |
| B2 | 641038 | 641038 | Torvaianica Litorale Nord | Basso | 100.00% |
| B2 | 409456 | 409456 | Torvaianica Litorale Sud | Medio | 100.00% |
| C1 | 895464 | 495035 | Campo Ascolano | Basso | 55.28% |
| C1 | 895464 | 392604 | | Medio | 43.84% |
| C2 | 1016185 | 185156 | Martin Pescatore | Basso | 18.22% |
| C2 | 1016185 | 831029 | | Medio | 81.78% |
| C3 | 477977 | 477977 | Torvaianica Alta | Medio | 100.00% |
| C4 | 719196 | 719196 | Campo Jemini | Medio | 100.00% |
| C5 | 198002 | 6618 | Colle Fiorito | Basso | 3.34% |
| C5 | 198002 | 191384 | | Medio | 96.66% |
| C6 | 2656892 | 824742 | Castagnetta | Alto | 31.04% |
| C6 | 2656892 | 1832150 | | Medio | 68.96% |
| C7 | 1353673 | 650611 | Cinque Poderi | Basso | 48.06% |
| C7 | 1353673 | 695922 | | Medio | 51.41% |
| C8 | 5826932 | 648565 | Santa Procula | Alto | 11.13% |
| C8 | 5826932 | 1906547 | | Basso | 32.72% |
| C8 | 5826932 | 3271787 | | Medio | 56.15% |
| D1 | 4288746 | 711473 | Santa Palomba | Alto | 16.59% |
| D1 | 4288746 | 3575331 | | Medio | 83.37% |
| D2 | 1419851 | 738465 | Via Naro e traverse | Alto | 52.01% |
| D2 | 1419851 | 680906 | | Medio | 47.96% |
| D3 | 3112541 | 3112541 | Via Campobello e traverse | Medio | 100.00% |
| D4 | 6120910 | 818103 | Via Laurentina e traverse | Alto | 13.37% |

| | | | | | |
|----|---------|---------|-----------------------------------|-------|---------|
| D4 | 6120910 | 5300020 | | Medio | 86.59% |
| | | | | | |
| D5 | 1415744 | 339458 | Via del Mare e traverse Nord | Alto | 23.98% |
| D5 | 1415744 | 344230 | | Basso | 24.31% |
| D5 | 1415744 | 732057 | | Medio | 51.71% |
| | | | | | |
| D5 | 540772 | 2980 | Via del Mare e traverse Sud | Basso | 0.55% |
| D5 | 540772 | 537792 | | Medio | 99.45% |
| | | | | | |
| D6 | 1031941 | 1031382 | Via Castelli Romani e traverse | Medio | 100.00% |
| | | | | | |
| D7 | 486006 | 166801 | Sedici Pini | Basso | 34.32% |
| D7 | 486006 | 319205 | | Medio | 65.68% |
| | | | | | |
| D8 | 371206 | 124354 | Colli di Enea | Basso | 33.50% |
| D8 | 371206 | 246852 | | Medio | 66.50% |
| | | | | | |
| E | 6966601 | 6394154 | Pratica di Mare | Alto | 91.78% |
| E | 6966601 | 71061 | | Basso | 1.02% |
| E | 6966601 | 501386 | | Medio | 7.20% |

This data was then also plotted in terms of percentage of surface area at risk according to the following chart.



Finally, based on the population data provided by the Municipality Registry Office, it was possible to process the data in terms of people exposed.

Unfortunately, the drawing of perimeters around the districts used in drafting the GIS, did not coincide perfectly with the perimeters of the districts as identified by the Registry Office, consequently mergers and exclusions were necessary to cross-reference the data. In any case, the difference is minimal and therefore of high statistical value. The population in the districts

amounts to 63518 individuals, while a total of 65556 people reside in the territory as a whole, with a delta, therefore, of 2038 people distributed on the territory living in scattered houses.

The population data table provided by the Registry Office is given below:

| District | Males | Females | Total |
|----------------------|--------------|--------------|--------------|
| 16_PINI_MACCHIOZZA | 378 | 350 | 728 |
| CAMPO ASCOLANO | 1790 | 1711 | 3501 |
| CAMPO JEMINI | 1000 | 997 | 1997 |
| CAMPOBELLO | 649 | 598 | 1247 |
| CASTAGNETTA | 753 | 731 | 1484 |
| COLLI DI ENEA | 1053 | 1063 | 2116 |
| MARTIN PESCATORE | 2283 | 2372 | 4655 |
| MINERVA_SUGHERETA | 772 | 750 | 1522 |
| MONTE D'ORO | 490 | 492 | 982 |
| MOTOMECCANICA | 252 | 264 | 516 |
| NUOVA LAVINIUM (167) | 2918 | 3130 | 6048 |
| POMEZIA CENTRO | 8180 | 8955 | 17135 |
| PRATICA DI MARE | 255 | 89 | 344 |
| ROMA 2 | 1082 | 992 | 2074 |
| SANTA PALOMBA | 184 | 131 | 315 |
| SANTA PROCULA | 1316 | 1286 | 2602 |
| TORVAJANICA | 6339 | 6138 | 12477 |
| TORVAJANICA ALTA | 1674 | 1676 | 3350 |
| VIA DEL MARE | 167 | 166 | 333 |
| VIA NARO | 1091 | 1039 | 2130 |
| TOTAL | 32626 | 32930 | 65556 |

It was therefore necessary to merge the following Zones:

- Monte d'Oro and Pratica di Mare in Pratica di Mare;
- Pomezia Centre and Nuova Lavinium in Pomezia centre;
- Roma 2 and Santa Palomba in Santa Palomba;
- Torvaianica Center with South coast and North coast in Torvaianica;
- Motomeccanica and Via del mare in Via del Mare and Intersecting Roads.
- Finally, Minerva Sughereta was excluded and inserted in the 'scattered houses' context.

This revision produced the following table:

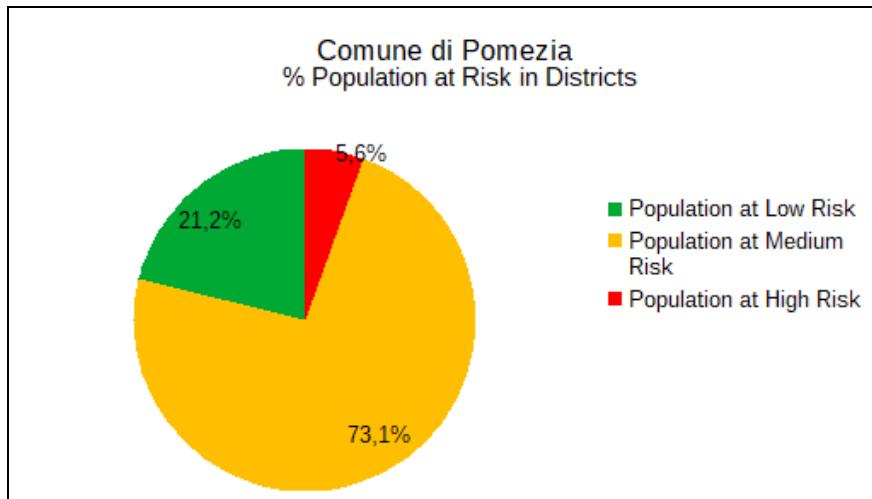
| Radon Indoor per District | | | | | | | |
|---------------------------|-------------------|---------------|--------------------|---------------------|-------|----------------|----------------------|
| Code | District AREA sqm | Risk Area sqm | District | District Population | Risk | % Area at Risk | % Population at Risk |
| A | 1799607 | 640396 | Pomezia Centro | 23183 | Basso | 35.59% | 8250 |
| A | 1799607 | 1159211 | | 23183 | Medio | 64.41% | 14933 |
| B1 | 1667379 | 667881 | Torvaianica Centro | 12477 | Basso | 4.35% | 543 |
| B1 | 1667379 | 999498 | - Litorale N e S | 12477 | Medio | 95.65% | 11934 |

| | | | | | | | |
|----|---------|---------|----------------------------------|-------|-------|---------|------|
| C1 | 895464 | 495035 | Campo Ascolano | 3501 | Basso | 55.28% | 1935 |
| C1 | 895464 | 392604 | | 3501 | Medio | 43.84% | 1535 |
| | | | | | | | |
| C2 | 1016185 | 185156 | Martin Pescatore | 4655 | Basso | 18.22% | 848 |
| C2 | 1016185 | 831029 | | 4655 | Medio | 81.78% | 3807 |
| | | | | | | | |
| C3 | 477977 | 477977 | Torvaianica Alta | 3350 | Medio | 100.00% | 3350 |
| | | | | | | | |
| C4 | 719196 | 719196 | Campo Jemini | 1997 | Medio | 100.00% | 1997 |
| | | | | | | | |
| C6 | 2656892 | 824742 | Castagnetta | 1484 | Alto | 31.04% | 461 |
| C6 | 2656892 | 1832150 | | 1484 | Medio | 68.96% | 1023 |
| | | | | | | | |
| C8 | 5826932 | 648565 | Santa Procula | 2602 | Alto | 11.13% | 290 |
| C8 | 5826932 | 1906547 | | 2602 | Basso | 32.72% | 851 |
| C8 | 5826932 | 3271787 | | 2602 | Medio | 56.15% | 1461 |
| | | | | | | | |
| D1 | 4288746 | 711473 | Santa Palomba | 2389 | Alto | 16.59% | 396 |
| D1 | 4288746 | 3575331 | | 2389 | Medio | 83.37% | 1992 |
| | | | | | | | |
| D2 | 1419851 | 738465 | Via Naro e traverse | 2130 | Alto | 52.01% | 1108 |
| D2 | 1419851 | 680906 | | 2130 | Medio | 47.96% | 1021 |
| | | | | | | | |
| D3 | 3112541 | 3112541 | Via Campobello e traverse | 1247 | Medio | 100.00% | 1247 |
| | | | | | | | |
| D5 | 1956516 | 339458 | Via del Mare e traverse N e S | 333 | Alto | 23.98% | 80 |
| D5 | 1956516 | 347210 | | 333 | Basso | 24.31% | 81 |
| D5 | 1956516 | 1269848 | | 333 | Medio | 51.71% | 172 |
| | | | | | | | |
| D7 | 486006 | 166801 | Sedici Pini | 728 | Basso | 34.32% | 250 |
| D7 | 486006 | 319205 | | 728 | Medio | 65.68% | 478 |
| | | | | | | | |
| D8 | 371206 | 124354 | Colli di Enea | 2116 | Basso | 33.50% | 709 |
| D8 | 371206 | 246852 | | 2116 | Medio | 66.50% | 1407 |
| | | | | | | | |
| E | 6966601 | 6394154 | Pratica di Mare | 1326 | Alto | 91.78% | 1217 |
| E | 6966601 | 71061 | | 1326 | Basso | 1.02% | 14 |
| E | 6966601 | 501386 | | 1326 | Medio | 7.20% | 95 |
| | | | | | | | |
| | | | District Population | 63518 | | | |
| | | | Total Population | 65556 | | | |

The method used to assess the risk percentage for the population involved attributing the resident population to each district and therefore, according to the class established on an area basis, to identify the number of people exposed as per the following table:

| Risk | No. People | % of Population |
|------------------------|------------|-----------------|
| Low Risk Population | 13481 | 21.2% |
| Medium Risk Population | 46453 | 73.1% |
| High Risk Population | 3551 | 5.6% |

Or:



From the data obtained it is clear that the territory of the Municipality of Pomezia requires particular attention in the construction of new buildings and the renovation of existing buildings. This concern has actually already found implementation with the approval of City Council Resolution no. 22 of 29/05/2014 which contains rules for the "prevention and protection from the risks of Radon Gas and natural endogenous gases during the planning, construction and maintenance of buildings".

Conclusions

10 percent of lung cancer deaths in Italy are linked to exposure to radon gas making it the second leading cause of lung cancer death after smoking.

The data released by the Italian National Institute of Health (ISS) indicates an average of around 3,300 radon-related deaths each year out of the approximately 34,000 deaths caused by lung cancer. A real "silent" massacre triggered by an insidious, odourless and colourless enemy that lurks in public buildings and in our homes and yet Radon is scarcely talked about and our institutions run no awareness campaigns.

For example, the number of road accident victims is reported; according to ISTAT (Italian National Statistics Institute) 3,378 people were killed on the road in 2017, almost the same number of people were victims of Radon.

And yet, despite this incidence, while there are numerous road traffic accident awareness campaigns disseminated via various media forms (radio, television, public information films, etc.) absolutely nothing has been done to make families aware of risks associated with Radon.

This work, requested by the Municipal Administration of Pomezia, represents not only a formidable tool for territorial planning but also a valid aid in raising awareness on primary prevention which is almost completely unknown to our health institutions.

As clearly emerges from this study, correct Radon risk planning is carried out through the Soil Radon surveys to which Indoor Radon data can provide a useful knowledge contribution.

On the other hand, knowledge of indoor radon represents a fundamental step for assessing the population's exposure to radon. These two aspects therefore have different purposes and must contribute to a better and in-depth knowledge of the territory and health risks to which the population is exposed.

The use of GIS, i.e. the territorial information system has been usefully exploited to allow for not only the usual geo-processing activities but also for targeted queries on urbanized and non-urbanized areas of the territory, making it possible to know the potential detailed risk of a single road.

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ANNEX 1 - Data Used for the GIS

The coordinate values refer to UTM zone 33T projection on Map Datum WGS84

| id_no | lat | long | Quartiere | no_serie | giorni | Bqmc |
|-------|---------|--------|----------------|----------|--------|------|
| 8978 | 4613902 | 290429 | 16 Pini | 16130 | 591 | 74 |
| 8978 | 4613902 | 290429 | 16 Pini | 16129 | 591 | 81 |
| 8846 | 4614019 | 290551 | 16 Pini | 15341 | 230 | 84 |
| 8893 | 4614111 | 290655 | 16 Pini | 15837 | 187 | 85 |
| 8846 | 4614019 | 290551 | 16 Pini | 15351 | 230 | 113 |
| 8484 | 4613869 | 290569 | 16 Pini | 14161 | 182 | 136 |
| 8893 | 4614111 | 290655 | 16 Pini | 15838 | 183 | 232 |
| 8575 | 4615053 | 285555 | Campo Ascolano | 14558 | 349 | 53 |
| 8578 | 4613723 | 286165 | Campo Ascolano | 14562 | 344 | 72 |
| 8645 | 4615073 | 285638 | Campo Ascolano | 14853 | 680 | 73 |
| 8645 | 4615073 | 285638 | Campo Ascolano | 14854 | 680 | 77 |
| 8557 | 4614187 | 286080 | Campo Ascolano | 14353 | 220 | 80 |
| 8997 | 4614654 | 286000 | Campo Ascolano | 16163 | 368 | 114 |
| 8556 | 4614171 | 286093 | Campo Ascolano | 14292 | 363 | 117 |
| 8997 | 4614654 | 286000 | Campo Ascolano | 16162 | 368 | 121 |
| 8566 | 4614844 | 285847 | Campo Ascolano | 14543 | 182 | 130 |
| 8566 | 4614844 | 285847 | Campo Ascolano | 14544 | 182 | 133 |
| 8527 | 4615280 | 285540 | Campo Ascolano | 14064 | 188 | 180 |
| 8841 | 4614561 | 285921 | Campo Ascolano | 22084 | 243 | 180 |
| 8841 | 4614561 | 285921 | Campo Ascolano | 21865 | 243 | 216 |
| 8841 | 4614561 | 285921 | Campo Ascolano | 15434 | 243 | 279 |
| 8644 | 4615102 | 285639 | Campo Ascolano | 14851 | 688 | 339 |
| 8644 | 4615102 | 285639 | Campo Ascolano | 14852 | 688 | 388 |
| 8841 | 4614561 | 285921 | Campo Ascolano | 22183 | 243 | 475 |
| 8841 | 4614561 | 285921 | Campo Ascolano | 15433 | 142 | 1109 |
| 8553 | 4610535 | 292168 | Campo Jemini | 14321 | 738 | 57 |
| 8553 | 4610535 | 292168 | Campo Jemini | 14322 | 738 | 72 |
| 8514 | 4611719 | 292599 | Campo Jemini | 14343 | 263 | 85 |
| 8514 | 4611719 | 292599 | Campo Jemini | 14352 | 263 | 94 |
| 8552 | 4610536 | 292172 | Campo Jemini | 14318 | 107 | 100 |
| 8552 | 4610536 | 292172 | Campo Jemini | 14319 | 107 | 109 |
| 8502 | 4611350 | 292559 | Campo Jemini | 14259 | 300 | 113 |
| 8935 | 4611542 | 292870 | Campo Jemini | 16031 | 365 | 115 |
| 8502 | 4611350 | 292559 | Campo Jemini | 14247 | 300 | 127 |
| 8935 | 4611542 | 292870 | Campo Jemini | 16032 | 365 | 140 |
| 7380 | 4611624 | 292624 | Campo Jemini | 14157 | 368 | 141 |
| 7380 | 4611624 | 292624 | Campo Jemini | 13555 | 368 | 149 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|---------------|-------|-----|------|
| 8854 | 4611710 | 293171 | Campo Jemini | 15416 | 381 | 357 |
| 8854 | 4611710 | 293171 | Campo Jemini | 15413 | 381 | 467 |
| 8490 | 4615539 | 293709 | Campobello | 13858 | 812 | 92 |
| 8745 | 4615544 | 293705 | Campobello | 15384 | 495 | 185 |
| 8745 | 4615544 | 293705 | Campobello | 15383 | 495 | 281 |
| 8895 | 4614321 | 292129 | Case sparse | 15843 | 301 | 83 |
| 8912 | 4614571 | 291851 | Case sparse | 15944 | 618 | 87 |
| 8879 | 4614240 | 292159 | Case sparse | 15391 | 253 | 120 |
| 8542 | 4613581 | 294101 | Castagnetta | 14194 | 192 | 92 |
| 8647 | 4613674 | 294396 | Castagnetta | 14856 | 172 | 147 |
| 8647 | 4613674 | 294396 | Castagnetta | 14855 | 172 | 151 |
| 8991 | 4612940 | 293409 | Castagnetta | 16148 | 183 | 158 |
| 8991 | 4612940 | 293409 | Castagnetta | 16147 | 183 | 169 |
| 8995 | 4612557 | 293938 | Castagnetta | 16154 | 193 | 192 |
| 8542 | 4613581 | 294101 | Castagnetta | 14195 | 192 | 195 |
| 8548 | 4614137 | 293423 | Castagnetta | 14201 | 567 | 237 |
| 8848 | 4613534 | 294383 | Castagnetta | 15538 | 365 | 259 |
| 8543 | 4613505 | 294023 | Castagnetta | 14212 | 265 | 287 |
| 8543 | 4613505 | 294023 | Castagnetta | 14211 | 271 | 367 |
| 8548 | 4614137 | 293423 | Castagnetta | 14202 | 567 | 370 |
| 8995 | 4612557 | 293938 | Castagnetta | 16155 | 193 | 381 |
| 8848 | 4613534 | 294383 | Castagnetta | 15537 | 365 | 565 |
| 8884 | 4613938 | 293715 | Castagnetta | 15621 | 238 | 693 |
| 8883 | 4613952 | 293457 | Castagnetta | 15617 | 179 | 720 |
| 8883 | 4613952 | 293457 | Castagnetta | 15616 | 179 | 748 |
| 8884 | 4613938 | 293715 | Castagnetta | 15620 | 240 | 1875 |
| 8609 | 4614760 | 294273 | Cinque Poderi | 14645 | 65 | 10 |
| 8611 | 4614638 | 294214 | Cinque Poderi | 14647 | 156 | 93 |
| 8701 | 4615094 | 294634 | Cinque Poderi | 15218 | 215 | 112 |
| 8611 | 4614638 | 294214 | Cinque Poderi | 14646 | 156 | 113 |
| 8702 | 4615091 | 294629 | Cinque Poderi | 15211 | 215 | 133 |
| 8608 | 4614760 | 294272 | Cinque Poderi | 14644 | 188 | 142 |
| 8608 | 4614760 | 294272 | Cinque Poderi | 14643 | 188 | 155 |
| 8702 | 4615091 | 294629 | Cinque Poderi | 15210 | 215 | 234 |
| 8501 | 4614593 | 291326 | Colli di Enea | 14242 | 186 | 43 |
| 8687 | 4614876 | 291756 | Colli di Enea | 15135 | 314 | 64 |
| 8538 | 4614733 | 291177 | Colli di Enea | 14164 | 300 | 68 |
| 8684 | 4614738 | 291180 | Colli di Enea | 15137 | 353 | 71 |
| 8678 | 4614637 | 291309 | Colli di Enea | 15140 | 686 | 75 |
| 8953 | 4614495 | 290872 | Colli di Enea | 16138 | 411 | 81 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|------------------|-------|-----|-----|
| 8953 | 4614495 | 290872 | Colli di Enea | 16139 | 411 | 81 |
| 8494 | 4614489 | 290874 | Colli di Enea | 14236 | 766 | 96 |
| 8513 | 4614713 | 290838 | Colli di Enea | 14345 | 336 | 99 |
| 8685 | 4614723 | 291223 | Colli di Enea | 15046 | 366 | 104 |
| 8513 | 4614713 | 290838 | Colli di Enea | 14344 | 336 | 158 |
| 8877 | 4614496 | 290883 | Colli di Enea | 15389 | 196 | 180 |
| 8877 | 4614496 | 290883 | Colli di Enea | 15388 | 196 | 208 |
| 8803 | 4614479 | 291127 | Colli di Enea | 15308 | 368 | 351 |
| 8803 | 4614479 | 291127 | Colli di Enea | 15309 | 368 | 458 |
| 8535 | 4612185 | 289801 | Martin Pescatore | 14180 | 184 | 55 |
| 8030 | 4611531 | 288969 | Martin Pescatore | 14372 | 141 | 67 |
| 8524 | 4611547 | 289497 | Martin Pescatore | 14181 | 348 | 74 |
| 8859 | 4611834 | 289278 | Martin Pescatore | 15732 | 431 | 74 |
| 8030 | 4611531 | 288969 | Martin Pescatore | 14373 | 139 | 78 |
| 8562 | 4611770 | 288934 | Martin Pescatore | 14375 | 132 | 78 |
| 8911 | 4611774 | 289312 | Martin Pescatore | 15949 | 536 | 81 |
| 8505 | 4612059 | 289441 | Martin Pescatore | 14241 | 305 | 81 |
| 8868 | 4611771 | 289322 | Martin Pescatore | 15549 | 464 | 85 |
| 8505 | 4612059 | 289441 | Martin Pescatore | 14261 | 305 | 86 |
| 8522 | 4611853 | 289267 | Martin Pescatore | 14248 | 361 | 86 |
| 8700 | 4611841 | 289137 | Martin Pescatore | 15144 | 423 | 92 |
| 8855 | 4611818 | 289318 | Martin Pescatore | 15746 | 633 | 93 |
| 8522 | 4611853 | 289267 | Martin Pescatore | 14166 | 361 | 95 |
| 8700 | 4611841 | 289137 | Martin Pescatore | 15143 | 423 | 97 |
| 8536 | 4612063 | 289440 | Martin Pescatore | 14198 | 181 | 97 |
| 8849 | 4612263 | 289733 | Martin Pescatore | 15349 | 367 | 112 |
| 8524 | 4611547 | 289497 | Martin Pescatore | 14182 | 348 | 113 |
| 8859 | 4611834 | 289278 | Martin Pescatore | 15731 | 431 | 113 |
| 8855 | 4611818 | 289318 | Martin Pescatore | 15745 | 631 | 116 |
| 8925 | 4612060 | 289783 | Martin Pescatore | 15895 | 607 | 118 |
| 8911 | 4611774 | 289312 | Martin Pescatore | 15950 | 536 | 120 |
| 8536 | 4612063 | 289440 | Martin Pescatore | 14199 | 181 | 122 |
| 8519 | 4611832 | 289660 | Martin Pescatore | 14169 | 255 | 129 |
| 8562 | 4611770 | 288934 | Martin Pescatore | 14374 | 132 | 130 |
| 8519 | 4611832 | 289660 | Martin Pescatore | 14168 | 255 | 130 |
| 8869 | 4612161 | 289685 | Martin Pescatore | 15672 | 478 | 131 |
| 8621 | 4611606 | 289103 | Martin Pescatore | 14763 | 364 | 144 |
| 8926 | 4611840 | 289733 | Martin Pescatore | 15897 | 394 | 146 |
| 8926 | 4611840 | 289733 | Martin Pescatore | 15898 | 394 | 153 |
| 8621 | 4611606 | 289103 | Martin Pescatore | 14762 | 364 | 167 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|------------------|-------|-----|-----|
| 8851 | 4612102 | 290141 | Martin Pescatore | 15312 | 568 | 181 |
| 8547 | 4611610 | 289227 | Martin Pescatore | 14291 | 369 | 182 |
| 8870 | 4611457 | 289016 | Martin Pescatore | 15680 | 480 | 221 |
| 8869 | 4612161 | 289685 | Martin Pescatore | 15675 | 479 | 257 |
| 8265 | 4611603 | 289036 | Martin Pescatore | 14173 | 224 | 286 |
| 8265 | 4611603 | 289036 | Martin Pescatore | 11371 | 196 | 323 |
| 8030 | 4611531 | 288969 | Martin Pescatore | 16933 | 354 | 377 |
| 8265 | 4611603 | 289036 | Martin Pescatore | 11372 | 196 | 382 |
| 8265 | 4611603 | 289036 | Martin Pescatore | 14175 | 224 | 387 |
| 8030 | 4611531 | 288969 | Martin Pescatore | 16934 | 355 | 481 |
| 8843 | 4611436 | 289032 | Martin Pescatore | 15239 | 361 | 495 |
| 8511 | 4615869 | 292419 | Pomezia Centro | 14232 | 486 | 41 |
| 8492 | 4615444 | 291578 | Pomezia Centro | 14254 | 555 | 47 |
| 8612 | 4616378 | 292083 | Pomezia Centro | 14651 | 388 | 53 |
| 8964 | 4615633 | 292076 | Pomezia Centro | 16231 | 405 | 55 |
| 8525 | 4615317 | 291834 | Pomezia Centro | 14174 | 349 | 59 |
| 8862 | 4616037 | 291680 | Pomezia Centro | 15733 | 598 | 62 |
| 8661 | 4615253 | 291872 | Pomezia Centro | 14944 | 420 | 63 |
| 8740 | 4615953 | 292188 | Pomezia Centro | 15234 | 333 | 63 |
| 8635 | 4615529 | 291528 | Pomezia Centro | 15033 | 369 | 63 |
| 8962 | 4615265 | 292248 | Pomezia Centro | 16142 | 385 | 64 |
| 8992 | 4615252 | 291882 | Pomezia Centro | 16149 | 209 | 64 |
| 8741 | 4615464 | 291571 | Pomezia Centro | 15235 | 293 | 66 |
| 8541 | 4614816 | 291727 | Pomezia Centro | 14179 | 126 | 66 |
| 8963 | 4615265 | 292249 | Pomezia Centro | 16043 | 385 | 69 |
| 8728 | 4616404 | 291725 | Pomezia Centro | 15250 | 522 | 71 |
| 8920 | 4615917 | 292213 | Pomezia Centro | 15846 | 373 | 72 |
| 8977 | 4615165 | 291609 | Pomezia Centro | 16126 | 533 | 73 |
| 8733 | 4615970 | 292384 | Pomezia Centro | 15241 | 312 | 75 |
| 8672 | 4615571 | 291607 | Pomezia Centro | 15016 | 286 | 75 |
| 8594 | 4615965 | 292191 | Pomezia Centro | 14750 | 696 | 77 |
| 8864 | 4615237 | 292122 | Pomezia Centro | 15744 | 645 | 80 |
| 8633 | 4615522 | 291528 | Pomezia Centro | 15037 | 364 | 83 |
| 8714 | 4615254 | 291871 | Pomezia Centro | 15223 | 371 | 83 |
| 8673 | 4615716 | 291848 | Pomezia Centro | 15025 | 293 | 84 |
| 8969 | 4614895 | 291694 | Pomezia Centro | 16136 | 427 | 84 |
| 8940 | 4614903 | 291754 | Pomezia Centro | 15909 | 607 | 85 |
| 8486 | 4615452 | 291520 | Pomezia Centro | 14160 | 337 | 85 |
| 8650 | 4615252 | 291870 | Pomezia Centro | 14939 | 217 | 86 |
| 8706 | 4615748 | 292074 | Pomezia Centro | 15217 | 342 | 87 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|-----------------|-------|-----|-----|
| 8671 | 4616456 | 291700 | Pomezia Centro | 15024 | 278 | 93 |
| 8746 | 4614704 | 291591 | Pomezia Centro | 15342 | 237 | 96 |
| 8840 | 4615045 | 291467 | Pomezia Centro | 15129 | 310 | 97 |
| 8593 | 4614874 | 291473 | Pomezia Centro | 14654 | 242 | 100 |
| 8597 | 4615537 | 291666 | Pomezia Centro | 14657 | 365 | 101 |
| 8886 | 4615482 | 291556 | Pomezia Centro | 15385 | 367 | 103 |
| 8597 | 4615537 | 291666 | Pomezia Centro | 14658 | 365 | 105 |
| 8892 | 4616074 | 292260 | Pomezia Centro | 15839 | 184 | 113 |
| 8699 | 4616391 | 292201 | Pomezia Centro | 15224 | 673 | 121 |
| 8696 | 4615047 | 291467 | Pomezia Centro | 15206 | 252 | 123 |
| 8638 | 4615251 | 291871 | Pomezia Centro | 15028 | 398 | 128 |
| 8695 | 4615486 | 291512 | Pomezia Centro | 15208 | 248 | 135 |
| 8667 | 4615857 | 292014 | Pomezia Centro | 15018 | 344 | 143 |
| 8592 | 4616532 | 292114 | Pomezia Centro | 14656 | 318 | 154 |
| 8980 | 4615831 | 292243 | Pomezia Centro | 16137 | 111 | 163 |
| 8660 | 4615859 | 292011 | Pomezia Centro | 15026 | 293 | 172 |
| 8595 | 4615732 | 291489 | Pomezia Centro | 14751 | 712 | 180 |
| 8520 | 4615587 | 291578 | Pomezia Centro | 14231 | 176 | 186 |
| 8737 | 4615825 | 292128 | Pomezia Centro | 15231 | 457 | 202 |
| 8881 | 4615617 | 292295 | Pomezia Centro | 15612 | 365 | 203 |
| 8739 | 4615827 | 292127 | Pomezia Centro | 15226 | 632 | 204 |
| 8881 | 4615617 | 292295 | Pomezia Centro | 15613 | 365 | 206 |
| 8665 | 4615857 | 292015 | Pomezia Centro | 15023 | 293 | 223 |
| 8658 | 4615860 | 292012 | Pomezia Centro | 15027 | 293 | 291 |
| 8915 | 4616074 | 292262 | Pomezia Centro | 15942 | 408 | 298 |
| 8738 | 4615807 | 292134 | Pomezia Centro | 15225 | 591 | 312 |
| 8666 | 4615859 | 292011 | Pomezia Centro | 15017 | 292 | 380 |
| 8520 | 4615587 | 291578 | Pomezia Centro | 14234 | 176 | 502 |
| 8695 | 4615486 | 291512 | Pomezia Centro | 15209 | 248 | 630 |
| 8744 | 4616000 | 292277 | Pomezia Centro | 15382 | 106 | 678 |
| 8491 | 4617254 | 290621 | Pratica di Mare | 14233 | 702 | 682 |
| 8761 | 4620233 | 298318 | Santa Palomba | 15446 | 518 | 72 |
| 8763 | 4620299 | 298434 | Santa Palomba | 15401 | 795 | 73 |
| 8812 | 4620422 | 297593 | Santa Palomba | 15194 | 368 | 76 |
| 8944 | 4620468 | 297549 | Santa Palomba | 15933 | 588 | 78 |
| 8834 | 4620399 | 297612 | Santa Palomba | 15130 | 632 | 80 |
| 8823 | 4620453 | 297477 | Santa Palomba | 15186 | 365 | 87 |
| 8822 | 4620120 | 297575 | Santa Palomba | 15185 | 535 | 90 |
| 8814 | 4620162 | 297584 | Santa Palomba | 15202 | 341 | 91 |
| 8833 | 4620491 | 297461 | Santa Palomba | 15127 | 293 | 91 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|---------------|-------|-----|------|
| 8836 | 4620440 | 297458 | Santa Palomba | 15131 | 339 | 97 |
| 8825 | 4620441 | 297476 | Santa Palomba | 15126 | 213 | 98 |
| 8951 | 4620450 | 297468 | Santa Palomba | 15934 | 539 | 101 |
| 8827 | 4620316 | 297540 | Santa Palomba | 15189 | 631 | 116 |
| 8820 | 4620192 | 297541 | Santa Palomba | 15200 | 637 | 122 |
| 8829 | 4620176 | 297601 | Santa Palomba | 15133 | 183 | 125 |
| 8818 | 4620177 | 297588 | Santa Palomba | 15198 | 337 | 127 |
| 8835 | 4620480 | 297456 | Santa Palomba | 15128 | 205 | 129 |
| 8793 | 4620266 | 298444 | Santa Palomba | 15418 | 651 | 138 |
| 8949 | 4620163 | 297580 | Santa Palomba | 15939 | 185 | 139 |
| 8778 | 4620264 | 298445 | Santa Palomba | 15244 | 219 | 156 |
| 8950 | 4620463 | 297555 | Santa Palomba | 15935 | 233 | 157 |
| 8759 | 4620234 | 298333 | Santa Palomba | 15346 | 429 | 166 |
| 8819 | 4620184 | 297566 | Santa Palomba | 15187 | 641 | 166 |
| 8808 | 4620470 | 297559 | Santa Palomba | 15197 | 345 | 168 |
| 8831 | 4620194 | 297532 | Santa Palomba | 15191 | 638 | 175 |
| 8764 | 4619986 | 298698 | Santa Palomba | 15424 | 418 | 179 |
| 8824 | 4620468 | 297475 | Santa Palomba | 15188 | 159 | 199 |
| 8807 | 4620484 | 297555 | Santa Palomba | 15195 | 244 | 217 |
| 8794 | 4620267 | 298439 | Santa Palomba | 15404 | 184 | 223 |
| 8776 | 4619475 | 297386 | Santa Palomba | 15400 | 441 | 230 |
| 8783 | 4619115 | 298184 | Santa Palomba | 15419 | 449 | 243 |
| 8749 | 4620278 | 298466 | Santa Palomba | 15394 | 503 | 330 |
| 8795 | 4620281 | 298466 | Santa Palomba | 15405 | 796 | 377 |
| 8757 | 4620276 | 298466 | Santa Palomba | 15428 | 512 | 428 |
| 8762 | 4620236 | 298335 | Santa Palomba | 15412 | 516 | 479 |
| 8777 | 4620224 | 298322 | Santa Palomba | 15442 | 530 | 571 |
| 8791 | 4620275 | 298462 | Santa Palomba | 15411 | 479 | 729 |
| 8772 | 4620222 | 298322 | Santa Palomba | 15431 | 530 | 964 |
| 8792 | 4620273 | 298464 | Santa Palomba | 15417 | 269 | 1448 |
| 8610 | 4616878 | 296217 | Santa Procula | 14649 | 188 | 56 |
| 8670 | 4615777 | 296070 | Santa Procula | 15022 | 290 | 94 |
| 8506 | 4615608 | 295412 | Santa Procula | 14227 | 785 | 133 |
| 8550 | 4617132 | 295765 | Santa Procula | 14320 | 176 | 169 |
| 8551 | 4617140 | 295766 | Santa Procula | 14183 | 175 | 197 |
| 8610 | 4616878 | 296217 | Santa Procula | 14650 | 188 | 244 |
| 8981 | 4616816 | 296137 | Santa Procula | 16229 | 184 | 311 |
| 8512 | 4617889 | 296164 | Santa Procula | 14238 | 660 | 451 |
| 8506 | 4615608 | 295412 | Santa Procula | 14229 | 785 | 453 |
| 8512 | 4617889 | 296164 | Santa Procula | 14249 | 660 | 548 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|------------------|-------|-----|------|
| 8981 | 4616816 | 296137 | Santa Procula | 16228 | 184 | 1493 |
| 8598 | 4610371 | 289022 | Torvaianica | 14752 | 181 | 66 |
| 8742 | 4612839 | 286885 | Torvaianica | 15227 | 287 | 77 |
| 8539 | 4611333 | 288149 | Torvaianica | 14207 | 380 | 83 |
| 8863 | 4612047 | 288117 | Torvaianica | 15740 | 183 | 91 |
| 8919 | 4610821 | 288553 | Torvaianica | 15890 | 360 | 91 |
| 8863 | 4612047 | 288117 | Torvaianica | 15738 | 185 | 98 |
| 8919 | 4610821 | 288553 | Torvaianica | 15889 | 360 | 98 |
| 8540 | 4611349 | 288178 | Torvaianica | 14154 | 380 | 114 |
| 8747 | 4613266 | 286679 | Torvaianica | 15347 | 323 | 115 |
| 8697 | 4611979 | 290090 | Torvaianica | 15205 | 281 | 138 |
| 8493 | 4609869 | 289400 | Torvaianica | 14237 | 652 | 142 |
| 8861 | 4611340 | 288194 | Torvaianica | 15674 | 398 | 150 |
| 8596 | 4611020 | 288843 | Torvaianica | 14753 | 184 | 159 |
| 8694 | 4610277 | 289282 | Torvaianica | 15147 | 281 | 194 |
| 8982 | 4610004 | 289207 | Torvaianica | 16234 | 184 | 221 |
| 8856 | 4610236 | 289015 | Torvaianica | 15670 | 614 | 283 |
| 8570 | 4612941 | 286746 | Torvaianica | 14381 | 723 | 324 |
| 8515 | 4612068 | 291622 | Torvaianica Alta | 14346 | 216 | 55 |
| 8523 | 4611763 | 291378 | Torvaianica alta | 14170 | 328 | 58 |
| 8571 | 4611890 | 291772 | Torvaianica Alta | 14459 | 286 | 61 |
| 8523 | 4611763 | 291378 | Torvaianica alta | 14171 | 328 | 62 |
| 8571 | 4611890 | 291772 | Torvaianica Alta | 14460 | 286 | 68 |
| 8515 | 4612068 | 291622 | Torvaianica Alta | 14230 | 216 | 72 |
| 8487 | 4609899 | 291656 | Torvaianica Alta | 14155 | 319 | 72 |
| 8487 | 4609899 | 291656 | Torvaianica Alta | 14163 | 319 | 76 |
| 8518 | 4612165 | 291255 | Torvaianica alta | 14177 | 144 | 83 |
| 8669 | 4612212 | 291148 | Torvaianica Alta | 14946 | 340 | 85 |
| 8891 | 4612204 | 291849 | Torvaianica Alta | 15832 | 202 | 101 |
| 8591 | 4611533 | 291800 | Torvaianica Alta | 14757 | 215 | 103 |
| 8518 | 4612165 | 291255 | Torvaianica alta | 14176 | 144 | 113 |
| 8891 | 4612204 | 291849 | Torvaianica Alta | 15833 | 202 | 117 |
| 8890 | 4611798 | 291627 | Torvaianica Alta | 15840 | 202 | 147 |
| 8591 | 4611533 | 291800 | Torvaianica Alta | 14749 | 215 | 148 |
| 8842 | 4611692 | 291756 | Torvaianica Alta | 15438 | 641 | 158 |
| 8842 | 4611692 | 291756 | Torvaianica Alta | 15437 | 641 | 172 |
| 8880 | 4612043 | 291749 | Torvaianica Alta | 15611 | 253 | 173 |
| 8890 | 4611798 | 291627 | Torvaianica Alta | 15841 | 202 | 178 |
| 8889 | 4611689 | 291512 | Torvaianica Alta | 15627 | 155 | 187 |
| 8880 | 4612043 | 291749 | Torvaianica Alta | 15610 | 253 | 212 |

ATINER CONFERENCE PRESENTATION SERIES No: GEL2019-0141

| | | | | | | |
|------|---------|--------|----------------------------|-------|-----|-----|
| 8639 | 4612013 | 291295 | Torvaianica Alta | 15049 | 527 | 220 |
| 8923 | 4612214 | 291830 | Torvaianica Alta | 15893 | 391 | 238 |
| 8485 | 4611243 | 291933 | Torvaianica Alta | 13552 | 416 | 323 |
| 8485 | 4611243 | 291933 | Torvaianica Alta | 14158 | 416 | 349 |
| 8889 | 4611689 | 291512 | Torvaianica Alta | 15628 | 155 | 450 |
| 8923 | 4612214 | 291830 | Torvaianica Alta | 15894 | 391 | 463 |
| 8499 | 4612036 | 291749 | Torvaianica Alta | 14228 | 398 | 470 |
| 8804 | 4617153 | 292022 | Via Castelli Romani e trav | 15307 | 269 | 116 |
| 8713 | 4617183 | 292035 | Via Castelli Romani e trav | 15228 | 372 | 327 |
| 8713 | 4617183 | 292035 | Via Castelli Romani e trav | 15229 | 371 | 410 |
| 8918 | 4613548 | 290408 | Via del Mare e traverse | 15891 | 358 | 152 |
| 8918 | 4613548 | 290408 | Via del Mare e traverse | 15892 | 358 | 201 |
| 8703 | 4615092 | 294627 | Via Laurentina e traverse | 15213 | 203 | 269 |
| 8703 | 4615092 | 294627 | Via Laurentina e traverse | 15214 | 203 | 320 |
| 8545 | 4617780 | 292309 | Via Naro | 13059 | 252 | 57 |
| 8510 | 4618206 | 292082 | Via Naro | 14350 | 363 | 128 |
| 8510 | 4618206 | 292082 | Via Naro | 14246 | 363 | 131 |
| 8630 | 4618005 | 291946 | Via Naro e traverse | 15031 | 190 | 139 |
| 8630 | 4618005 | 291946 | Via Naro e traverse | 15032 | 190 | 191 |
| 8631 | 4618003 | 291945 | Via Naro e traverse | 15030 | 190 | 333 |
| 8985 | 4613210 | 292491 | Viceré | 16238 | 184 | 100 |
| 8916 | 4612741 | 292367 | Viceré | 15947 | 239 | 152 |
| 8916 | 4612741 | 292367 | Viceré | 15946 | 239 | 170 |
| 8984 | 4613220 | 292488 | Viceré | 16236 | 185 | 184 |
| 8984 | 4613220 | 292488 | Viceré | 16237 | 185 | 291 |

ANNEX 2 – GIS MAPS

